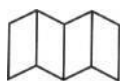


SOVIET *X-PLANES*



Yefim Gordon and Bill Gunston OBE FRAeS



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A view of the new Mikoyan 1.44.

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Glossary

ADD Aviatsiya Dal'nevo Deistviya
- Long Range Air Arm.

A-VMF Aviatsiya Voenno-Morskovo Flota
- Naval Air Force.

B Bombardirovshchik - as a prefix, bomber.

BB Blizhnii Bombardirovshchik
- as a prefix, short range bomber.

BBS Blizhny bombardirovshchik, skorostnoy
- short range bomber, high speed.

bis as a suffix, literally from the French or Latin 'again' or encore, more practically, a rethought or developed version, or even Mk.2. Designation used by only a few OKBs; e.g. MiG with their MiG-21 jet.

BOK Byuro Osobykh Konstruktsii
- Bureau of Special Design.

BSh Bronirovanny Shturmovik
- armoured attack aircraft.

cg Centre of Gravity.

D Dalny - as a suffix, long range.

DB Dalny Bombardirovshchik - long range bomber.

GKAT Gosudarstvenny Komitet Aviatsionnoi Tekhniki - State Committee for Aviation Equipment.

GKO Gosudarstvenny Komitet Oborony
- State Committee for Defence.

GUAP Glavnoye Upravleniye Aviatsionnoi Promyshlennosti - Chief Directorate of Aircraft Industry.

GUGVF Main directorate of Civil Aviation.

I Istrebitel - **as a** prefix, fighter, or literally 'destroyer' - see also **I** - Izdelie.

I Izdelie - as a prefix, product, or item, used by an OKB to denominate an airframe prior to acceptance, see also **I** - Istrebitel.

KhAI Kharkovskii Aviatsionnyi Institut
- Kharkov Aviation Institute.

KOSOS Konstruktorskii Otdel Opytnovo Samolyotostroeniya
- Experimental Aircraft Design Section.

LB-S Legky bombardirovshchik-sparka
- light bomber, two-seater.

LII Letno-Issledovatel'skii Institut - Ministry of Aviation Industry Flight Research Institute.

Nil Nauchno Issledovatel'skii Institut
- scientific and research institute (of WS).

MAI Moskovskii Aviatsionnyi Institut Sergo Ordjonitidze - Moscow Aviation Institute Sergo Ordjonitidze.

NKAP Narodny Komissariat Aviatsionnoi Promyshlennosti - State Commissariat for the Aviation Industry - People's Commissariat for Heavy Industry.

NKVD Narodny Komissariat Vnutrennikh Del
- People's Commissariat of Internal Affairs, forerunner of the KGB.

OKB Opytnoye Konstruktorskoye Byuro
- experimental construction bureau.

ON Osobogo Naznacheniya - as a suffix, personal assignment or special use.

PB Pikiruyushchii Bombardirovshchik
- **as a** suffix, dive bomber.

RKKA Red Army.

S Skorostnoy - as a prefix or suffix, high speed.

SB Skorostnoy Bombardirovshchik
- high speed bomber.

ShKAS Shpitalny-Komaritski Aviatsionny Skorostrelny - rapid-firing aircraft machine gun (designed by Shpitalny and Komaritski).

ShVAK Shpitalny-Vladimirov Aviatsionnaya Krupnokalibernaya - large calibre aircraft cannon (design by Shpitalny and Vladimirov).

SNII GVF scientific test institute.

SPB Skorostnoy Pikiruyushchy Bombardirovshchik - high speed dive bomber, also denominate the TB-3/Polikarpov Zveno composite.

T Torpedonosyets, as a suffix, torpedo.

T Tyazhelovooruzhenny - suffix, heavily armed.

TB Tyazhyoly Bombardirovshchik
- heavy bomber.

TsAGI Tsentral'nyi Aerogidrodinamicheskoy Institut - Central Aerodynamic and Hydrodynamic Institute.

TsIAM Tsentral'noye Institut Aviatsionnogo Motorostroeniya - Central Institute of Aviation Motors.

TsKB Tsentral'noye Konstruktorskoye Byuro - central, ie state, design bureau.

WS Voenno-vozdushniye Sily - air forces of USSR.

ZOK Factory for GVF experimental constructions.

Airframe and Engine Design Bureaux

Accepted abbreviations to denote airframe (surname only used for the abbreviation) or engine design (first name and surname) origin are as follows:

AM Alexander Mikulin

Ar Arkhangelsky, Aleksandr

ACh Aleksei Charomskii

ASh Arkadi Shvetsov

Be Beriev, G M

Gr Grushin, Pyotr

Gu Gudkov, Mikhail (see also LaGG)

II Ilyushin, Sergei (we have chosen to use the abbreviation IL in this work, to avoid confusion with the roman numeral II).

Ka Kamov, Nikolai

La Lavochkin, Semyon

LaG Lavochkin and Gorbunov

LaGG Lavochkin, Gorbunov and Gudkov (see also Gu)

MiG Mikoyan, Artyom and Gurevich, Mikhail

Pe Petlyakov, Vladimir

Po Polikarpov, Nikolay - but only applied to the U-2, which became the Po-2.

Su Sukhoi, Pavel

Ta Tairov, Vsevolod

Tu Tupolev, Andrei

VD Viktor Dobrynin

VK Vladimir Klimov

Yak Yakovlev, Alexander

Yer Yermolayev, Vladimir

Notes

Russian Language and Transliteration

Russian is a version of the Slavonic family of languages, more exactly part of the so-called 'Eastern' Slavonic grouping, including Russian, White Russian and Ukrainian. As such it uses the Cyrillic alphabet, which is in turn largely based upon that of the Greeks.

The language is phonetic - pronounced as written, or 'as seen'. Translating into or from English gives rise to many problems and the vast majority of these arise because English is not a straightforward language, offering many pitfalls of pronunciation!

Accordingly, Russian words must be translated through into a *phonetic* form of English and this can lead to different ways of helping the reader pronounce what he or she sees.

Every effort has been made to standardise this, but inevitably variations will creep in. While reading from source to source this might seem confusing and/or inaccurate but it is the name as *pronounced* that is the constancy, not the *spelling* of that pronunciation!

The 20th letter of the Russian (Cyrillic) alphabet looks very much like a 'Y' but is pronounced as a 'U' as in the word 'rule'.

Another example, though not taken up in this work, is the train of thought that Russian words ending in 'y' are perhaps better spelt out as 'yi' to underline the pronunciation, but it is felt that most Western speakers would have problems getting their tongues around this!

This is a good example of the sort of problem that some Western sources have suffered from in the past (and occasionally some get regurgitated even today) when they make the mental leap about what they see approximating to an English letter.

Measurements

In the narrative, all measurements are given in Imperial figures (of British FPSR - foot, pound, second, Rankine) and then decimal units (or SI - *Système International d'Unités*, established in 1960) second in brackets. The states that comprised the Soviet Union embraced the decimal system from the earliest days, although it should be noted that power was measured up to the Great Patriotic War, and beyond, using the established Western horsepower measurement.

The following explanations may help:

| | |
|--------------------------|--|
| aspect ratio | wingspan and chord expressed as a ratio. Low aspect ratio, short, stubby wing; high aspect ratio, long, narrow wing. |
| ft | feet - length, multiply by 0.305 to get metres (m). For height measurements involving service ceilings and cruise heights, the figure has been 'rounded'. |
| ft² | square feet - area, multiply by 0.093 to get square metres (m ²). |
| fuel | measured in both gallons/litres and pounds/kilograms. The specific gravity (sg) of Soviet fuel varied considerably during the War and conversions from volume to weight and vice versa are impossible without knowing the sg of the fuel at the time. |
| gallon | Imperial (or UK) gallon, multiply by 4.546 to get litres. (500 Imperial gallons equal 600 US gallons.) |
| hp | horsepower - power, measurement of power for piston engines. Multiply by 0.746 to get kilowatts (kW). |
| kg | kilogram - weight, multiply by 2.205 to get pounds (lb). |
| kg/cm² | kilogram per square centimetre - force or pressure, multiply by 14.224 to get pounds per square inch (lb/in ²). |
| km | kilometre - length, multiply by 0.621 to get miles. |
| km/h | kilometres per hour - velocity, multiply by 0.621 to get miles per hour (mph). |
| kW | kilowatt - power, measurement of power for piston engines. Multiply by 1.341 to get horse power. |
| lb | pound - weight, multiply by 0.454 to get kilograms (kg). Also used for the force measurement of turbojet engines, with the same conversion factor, as pounds of static thrust. |

| | |
|--------------------------|---|
| lb/ft² | pounds per square foot - force or pressure, multiply by 4.882 to get kilograms per square metre (kg/m ²). |
| litre | volume, multiply by 0.219 to get Imperial (or UK) gallons. |
| m | metre - length, multiply by 3.28 to get feet (ft). |
| mile | Imperial length, multiply by 1.609 to get kilometres (km). |
| m² | square metre - area, multiply by 10.764 to get square feet (ft ²). |
| mm | millimetre - length, the bore of guns is traditionally a decimal measure (eg 30mm) and no Imperial conversion is given. |
| mph | miles per hour - velocity, multiply by 1.609 to get kilometres per hour (km/h). |

Design and Illustration considerations

In this work we have utilised our well-proven format, aiming as always to provide a high level of readability and design.

A conscious decision was made to include peripheral details where they appear on the original illustrations; photographs have not been printed across the fold and cropping has been kept to an absolute minimum.

Unfortunately, in this work, many of the photographs received were copies of those from official sources and proved to be lacking in definition and tonal range. Although no effort has been spared to achieve the highest standard of reproduction, priority for inclusion has, of necessity, been given to historical significance over technical perfection.

Introduction

For over 70 years from 1918 the world's largest country was tightly controlled by a tiny group of elderly men in The Kremlin, in Moscow. Their power was absolute. They could take giant decisions, and so could make giant mistakes. They also sometimes found they had to choose between diametrically opposed objectives. While on the one hand aviation was a marvellous instrument for propaganda, trumpeting the achievements of the Soviet Union, the underlying theme of Soviet society was of rigid secrecy.

Thus, when The Great Patriotic War began on 22nd June 1941 the outside world knew very little about Soviet aircraft. The knowledge was confined largely to the mass-produced Polikarpov biplane fighters and Tupolev monoplane bombers, and to the ANT-25 monoplane designed to break world distance records. Only very gradually did it become apparent that the austere and sombre Land of the Soviets (this was the name of a record-breaking bomber) was home to an incredible diversity of aircraft.

Other countries - the USA, France, Britain, Italy and increasingly Germany - had numerous aircraft companies from which flowed many hundreds of different types of aircraft. They also had individuals who sometimes managed to create aircraft and even form tiny companies, but the aircraft were invariably conventional lightplanes aimed at the private owner. Few people in what became called The West' would have dreamed that in Stalin's realm individuals could even set their sights on high-powered fast aircraft bristling with strange ideas.

At the same time, the Soviet Union was far from being the earthly paradise that was originally intended. It is said that power corrupts, and the record shows that anyone who 'stuck his head above the parapet' was likely to get it cut off. It seems incredible that in 1936-40 Stalin should have been able to unleash what was called The Terror, in which anyone who might have posed the slightest threat - for example, any senior officer in any of the armed forces - was simply put through a show trial on invented charges and shot.

In the aircraft industry, time after time people who made mistakes, or in some way fell foul of someone more senior, were simply dismissed or even imprisoned (and in a few cases, executed). It is beyond question that this omnipresent air of repression did much to counter the natural enthusiasm of countless workers who longed for their country to be the greatest on Earth, and a leader in advanced technology. When one reads what happened it seems remarkable that so many diverse aircraft actually got built.

This book is the most comprehensive attempt yet to collect the stories of the more important of these X-Planes (experimental aircraft) into one volume. Of course, some of the strange flying machines featured were built after the collapse of the Soviet Union, but we did not want a ponderous title. Translation of the Communist state into an intensely capitalist one has tended to concentrate the mind wonderfully. Whereas 60 years ago Soviet designers could obtain funds for often bizarre ideas which a hard-nosed financial director would have considered an almost

certain non-starter, today Ivan at his modern keyboard and screen knows that if he gets it wrong his shaky firm will go out of business.

Ironically, instead of being a closely guarded secret, the experimental aircraft and projects of the Soviet Union are today better documented than those of many Western companies. The process of rationalization has seen almost all the famous names of the aircraft industries of the UK, USA and France disappear. In many cases, and especially in the UK, their irreplaceable archives have been wantonly destroyed, as being of no interest to current business. We may never know what strange things their designers drew on paper but never saw built. In contrast, the Soviet Union never destroyed anything, unless there was a political reason for doing so. Accordingly, though this book concentrates on hardware, it also includes many projects which were built but never flew, and even a few which never got off the proverbial drawing board.

As in several previous books, Yefim Gordon provided much information and most of the illustrations while Bill Gunston wrote the text and put the package together. The in-flight photograph of the MiG 1.44 featured on the jacket is from a Mikoyan video. A special vote of thanks is due to Nigel Eastaway and the Russian Aviation Research Trust who provided the remainder of the visual images.

Sukhoi S-37 experimental fighter.



SOVIET X-PLANES

Arranged principally in alphabetical order

Alekseyev I-218

Purpose: To provide a high-performance Shturmovik, armoured ground-attack aircraft.

Design Bureau: Semyon Mikhailovich Alekseyev OKB-21, at Gorkii.

Born in 1909, Alekseyev graduated from MAI in 1937, and became one of the principal designers in the OKB of S A Lavochkin. Responsible for major features of the LaGG-3 and La-5 family of fighters, he was head of detail design on the derived La-7 and La-9. In 1946 he was able to open his own design bureau. He at once concentrated on twin-jet fighters with nosewheel landing gear, getting the

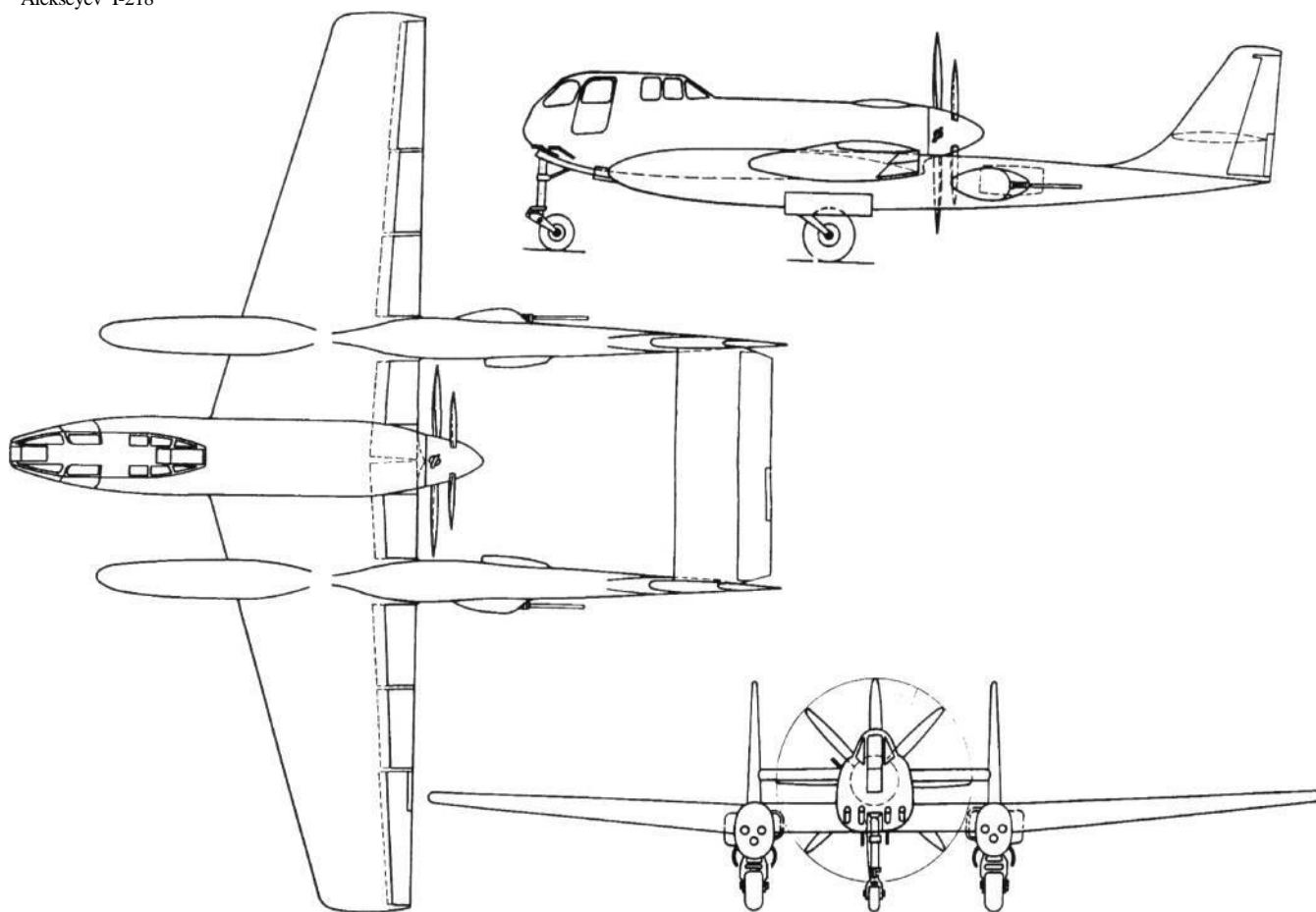
I-211 into flight test on 13th October 1947. Whilst working on derived aircraft with more powerful engines and swept wings, he worked in parallel on a family of multirole ground-attack aircraft.

The first of these was the I-218, or I-218-1. For various reasons, the most important being the need for long endurance at low altitude, Alekseyev adopted a powerful piston engine. He adopted a pusher layout, with the tail carried on twin booms.

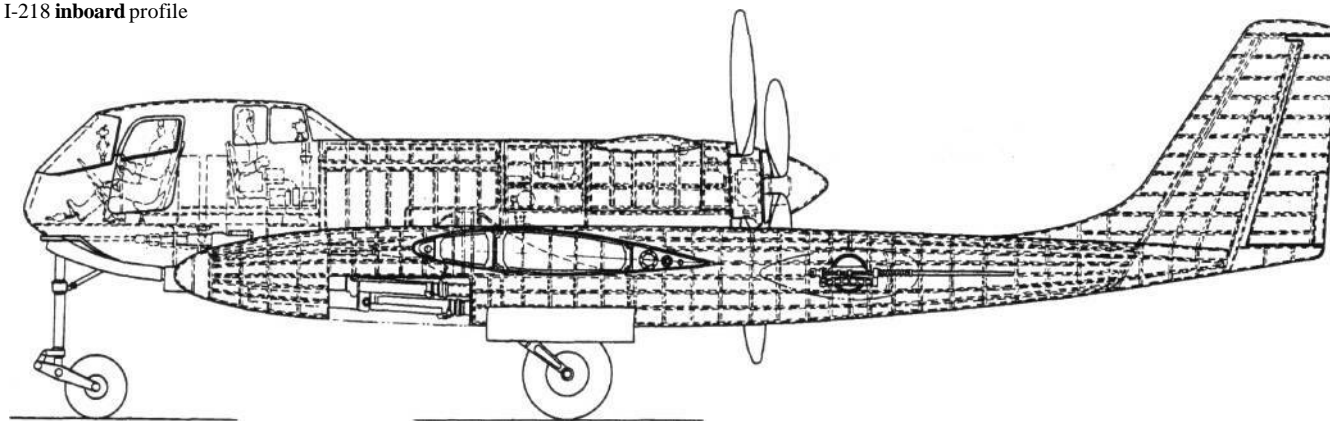
A single prototype was completed in summer 1948, but in August of that year OKB-21 was closed. (A contributory factor was Yakovlev's scathing comment that Alekseyev's jet

fighters were copies of the Me 262.) At closure three derived aircraft were on the drawing board. The I-218-Ib (I-219) had a revised crew compartment, tailwheel landing gears and swept vertical tails. The I-218-11 (I-221) was an enlarged aircraft with a conventional fuselage and tail, powered by a Lyul'ka TR-3 turbojet, which was being developed to give 4,600kg (10,141 lb) thrust. The I-218-III (I-220) was a variation on the 218-11 with a very powerful piston engine (he hoped to get a Dobrynin VD-4 of 4,000hp, as used in the Tu-85 but without the turbo). Alekseyev was sent to CAHI (TsAGI) and then as Chief Constructor to the OKB-1 team of former German (mainly

Alekseyev I-218



I-218 inboard profile



Junkers) engineers to produce the Type 150, described later under OKB-1.

No detailed documents have been discovered, but the I-218 was a modern all-metal stressed-skin aircraft designed to a high (fighter type) load factor. The wing comprised a centre section and outer panels joined immediately outboard of the tail booms. It was tapered on the leading edge only, and on the trailing edge were fitted outboard ailerons and six sections of area-increasing flap. The tail booms projected far in front of the wing, and carried a conventional twin-finned tail with a fixed tailplane joining the fins just above the centreline of the propeller.

The forward fuselage contained a compartment for the pilot and for the aft-facing gunner. Like some highly-stressed parts of the airframe this was made of the new 30-KhGSNA chrome-nickel steel, and it was thick enough to form a 'bathtub' to protect against armour-piercing shells of 20mm calibre. The windows were very thick multilayer glass/plastics slabs. The engine, mounted on

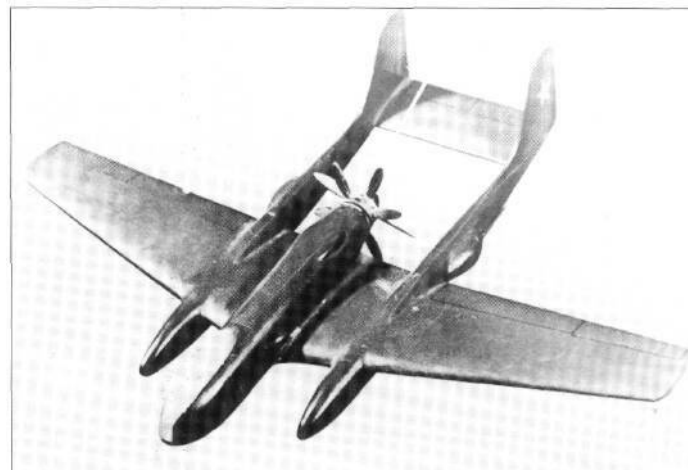
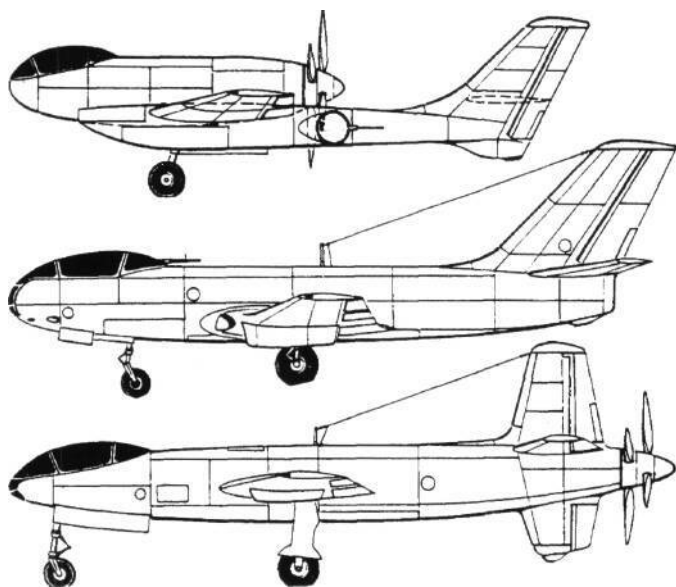
the wing, was a Dobrynin VM-251 (in effect, half a VD-4, with three banks each of four cylinders) rated at 2,000hp. It drove an AV-28 contra-rotating propeller arranged for pusher propulsion, comprising two three-blade units each of 3.6m (11ft 10in) diameter.

The I-218 was intended to have heavy forward-firing armament, such as four NR-23 guns each with 150 rounds or two N-57 (30 rounds each) and two N-37 (40 rounds each). In addition provision was to be made for up to 1,500kg (3,307 lb) of bombs or other stores, carried mainly under the fuselage, or six 132mm (5.2in) rockets or 16 RS-82 rockets carried under the wings.

For defence, the backseater could operate a remotely-sighted system controlling an NR-23 cannon on the outer side of each tail boom. Each of these powerful guns was fed from a 120-round magazine, and was mounted in a powered barbette with angular limits of $\pm 25^\circ$ vertically and 50° outwards. Avionics included 12RSU-10 radio, RPKO-10M radio-compass, RV-2 radar altimeter and SPU-5 intercom.

Though the I-218 was built there is no positive evidence that it flew, apart from the fact that the specification does not include the word 'estimated' for the flight performance. The fact is, in 1948 such aircraft were regarded as obsolescent. A rival, also abandoned, was the IL-20, described later.

| | | |
|--------------------------|------------------|----------------------|
| Dimensions | | |
| Span | 16.43m | 53 ft M in |
| Length | 13.88m | 45 ft & A in |
| Wing area | 45m ² | 484.4ft ² |
| Weights (unknown except) | | |
| Normal loaded weight | 9,000kg | 19,840lb |
| Maximum | 10,500kg | 23,148lb |
| Performance | | |
| Max speed, at sea level | 465km/h | 289 mph |
| at 2,000m (6,562 ft) | 530km/h | 329 mph |
| Take-off run | 520m | 1,706ft |
| Landing run | 600m | 1,969ft |
| Time to reach 5,000 m | 5min | 16,400ft |
| Service ceiling | 6,000 m | 21,650ft |
| Range | 1,200km | 746 miles |



Above: I-218 model.

Left: Alekseyev's ground-attack aircraft projects, from the top -I-218-IB, I-218-II and I-218-III.

Antonov LEM-2

Purpose: To investigate the maximum load that could be carried by an aeroplane powered by a single M-11 engine.

Rivals included the Grokhovskii G-31 and KhAI-3, both described later.

Design Bureau: Oleg K Antonov, Kiev.

The idea was that of L E Malinovskii, Director of the Civil Aviation Scientific-Technical Institute (hence the designation). AviAvnito and Osoaviakhim (the Society of Friends of Aviation and the Chemical Industry) provided funds in 1936, enabling the Kiev (Ukraine) constructor to create his first powered aircraft. The single example built was given the OKB designation of OKA-33, because it was their 33rd design. The flight-test programme was opened by test pilot N I Ferosyev on 20th April 1937. Results were satisfactory.

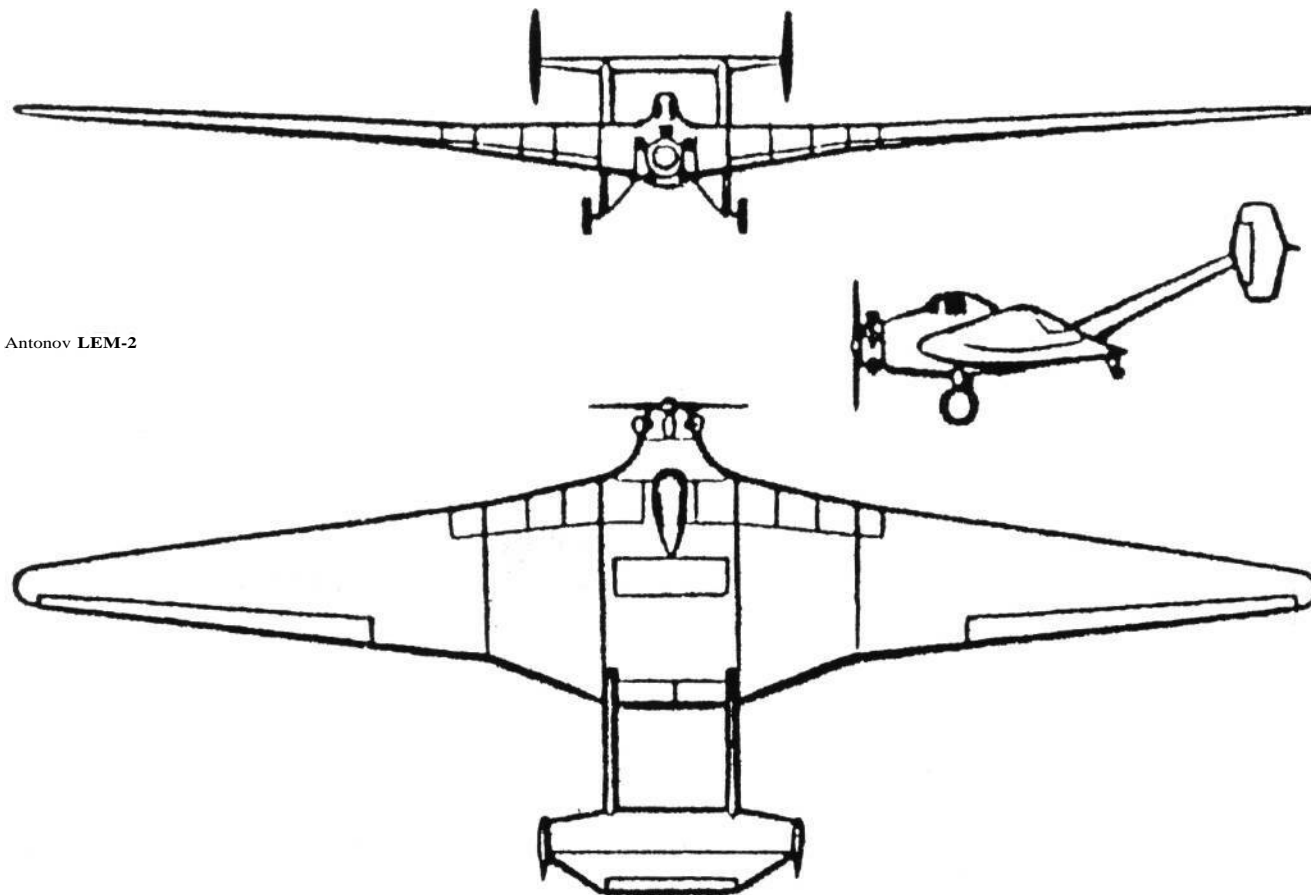
The LEM-2 was predictably almost a flying wing, based on the aerodynamics of Prof V N Belyayev, with a PZ-2 aerofoil modified from the common CAHI (TsAGI) R-11. The M-11 five-cylinder radial, rated at 100hp, was mounted on the front in a long-chord cowl-

ing, driving a two-blade carved-wood propeller of the type mass-produced for the U-2 (later called Po-2). Construction was almost entirely wood, with ply skins of varying thickness. The wing comprised a centre section and two outer panels with long-span but narrow ailerons. The inboard part of the wing had a chord of 6.7m (22ft) and so was deep enough (1.47m, 4ft 10in) to house the payload of 1,280kg (2,822 lb). The payload compartment between the spars measured 2.4 x 1.5 x 1.2m (7'10 1/2" x 4'11" x 3'11"). In the LEM-2 built the pilot was the only occupant, though it was the intention that a production aircraft should have provision for 11 passenger seats. Access to the main payload space was to be via large doors in the leading edge ahead of the front spar, but these were absent from the LEM-2 built. There was also a door in the upper surface behind the cockpit. The twin-finned tail was carried on two upswept booms attached at the extremities of the wing centre section. Landing gears comprised two main wheels (the intended spats were never fitted) attached to the centre-section end ribs,

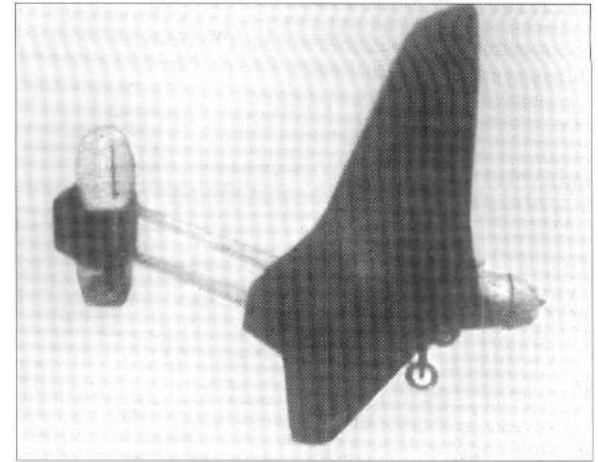
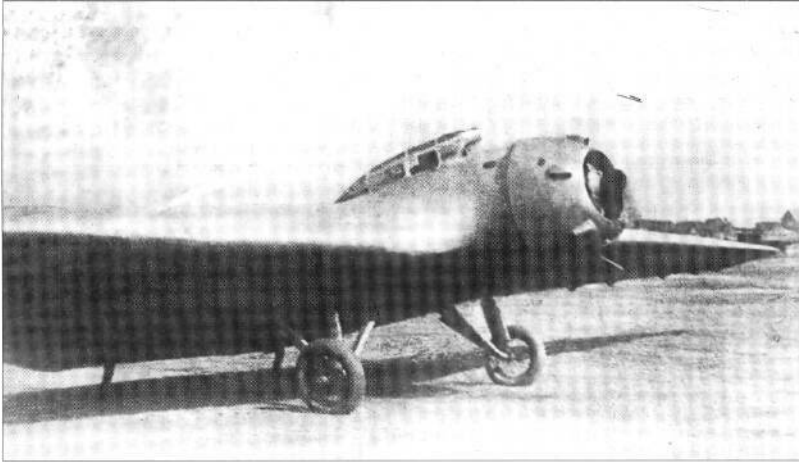
and a skid under the trailing edge.

Development of aircraft in this class was soon discontinued, it being decided they were of limited practical use. In fact, especially with slightly more power, they could have been used in the USSR in large numbers in huge regions devoid of roads and railways.

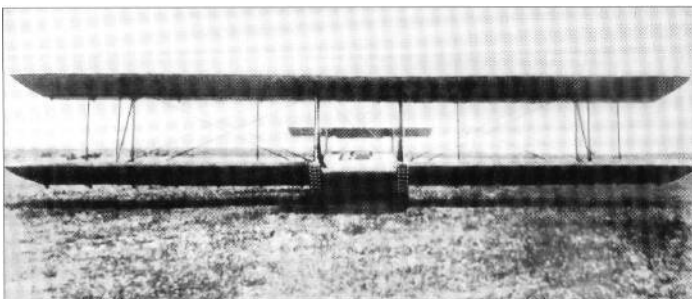
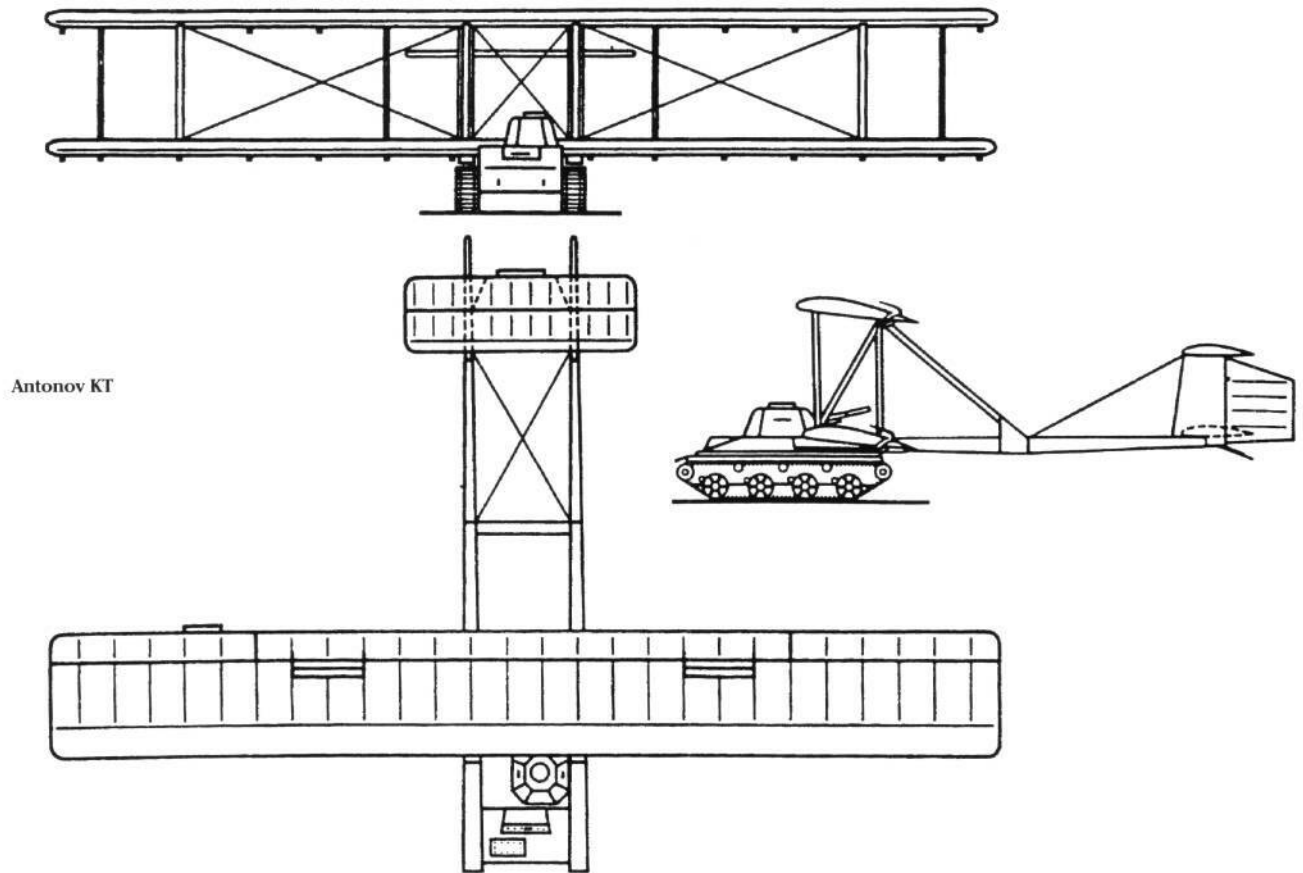
| Dimensions | | |
|-----------------|--------------------|--------------------|
| Span | 27.6m | 90 ft 8 in |
| Length | 10.6m | 34 ft 9 in |
| Wing area | 81.4m ² | 876ft ² |
| Weights | | |
| Weight empty | 1,640kg | 3,616 lb |
| Maximum loaded | 2,920kg | 6,437 lb |
| Performance | | |
| Maximum speed | 117km/h | 72.7 mph |
| Cruising speed | 100km/h | 62 mph |
| Service ceiling | 1,500m | 4,920ft |
| Intended range | 900km | 559 miles |



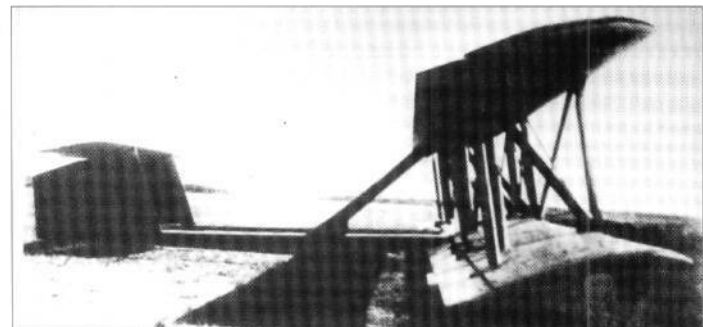
Antonov LEM-2



Two views of the LEM-2, OKA-33.



Front and side views of KT assembled on tank.



Antonov A-40, KT

Purpose: KT, Kryl'ya Tanka, flying tank, a means for delivering armoured vehicles to difficult locations by fitting them with wings.

Design Bureau: Oleg Konstantinovich Antonov, at Kiev.

From 1932 the Soviet high command studied all aspects of the new subject of airborne warfare, including parachute troops and every kind of aerial close support of armies. One novel concept was fitting wings (with or without propulsion) to an armoured vehicle. Simple tests were carried out with small cars and trucks, converted into gliders and towed by such aircraft as the R-5 and (it is believed) a TB-1. There was even a project to fit wings to a T-34, weighing 32 tonnes, using a pair of ANT-20b/sastugs!

The KT was the only purpose-designed winged tank actually to be tested. The chosen tank was the T-60, specially designed for airborne forces. Antonov designed a large biplane glider and flight controls to fit over the tank. The work was delayed by the German invasion of 22nd June 1941, but the prototype

was ready for test in early 1942. The selected pilot, S N Anokhin, did a quick course in tank driving and was then towed off by a TB-3. He managed to land without injuring himself or overturning the tank, which was drivable afterwards.

The glider was officially designated A-T, and A-40 by the Antonov OKB. It comprised rectangular biplane wings joined by vertical and diagonal struts with wire bracing. Both wings were fitted with ailerons, joined by vertical struts. The upper wing also had two spoiler airbrakes, while the lower wing had full-span flaps which the pilot (who was the tank driver) could pull down manually prior to the landing. At the rear was the twin-finned semi-biplane tail, attached by two braced booms. Construction was of wood, mainly spruce. The covering was fabric, with plywood over the booms and some other areas. The airframe was lifted by crane over the tank and secured by latches. The towrope from the tug was attached to the tank, and cast off by the tank driver when close to the target. The intention was that he should glide down

steeply, lower the flaps and then, when about to touch the ground, pull a lever to jettison the glider portion. The tank would then be left ready for action. The tank's tracks were driven through an overdrive top gear to assist take-off and smooth the landing.

Though the single test flight was successful, Anokhin, an outstandingly skilled pilot, found his task extremely tricky. He doubted the ability of ordinary 'tankers' to fly the loaded tank and bring it down to a successful landing. In any case, the real need was to fly in T-34s, and there seemed to be no practical way of doing this.

| | | |
|------------------------|--------------------|--------------------------------------|
| Dimensions | | |
| Span | 18.0m | 59 ft ³ / ₄ in |
| Length, excluding tank | 12.06m | 39ft6 ³ / ₄ in |
| Wing area | 85.8m ² | 923.6ft ² |
| Weights | | |
| Weight (airframe) | 2,004 kg | 4,418lb |
| with T-60 | 7,804 kg | 17,205 lb |
| Performance | | |
| Towing speed | 120km/h | 74.6 mph |

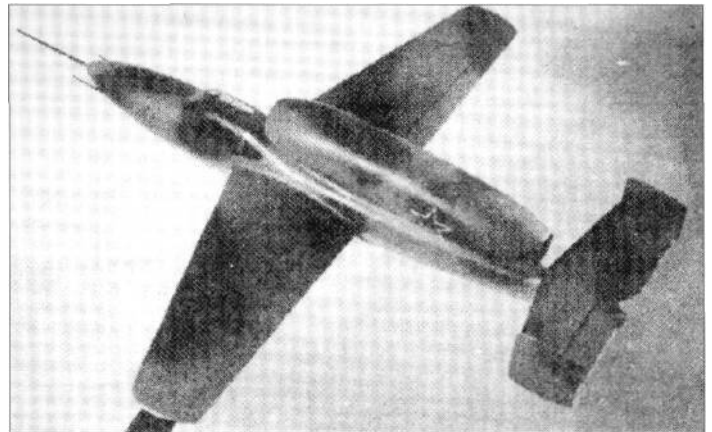
Antonov M

Purpose: To create a superior jet fighter.

Design Bureau: No 153, Oleg K Antonov, Novosibirsk.

In 1945 Antonov was impressed by the German He 162, and considered it a good way to produce a simple fighter for rough-field use powered by a single turbojet. In spring 1947 his staff had completed the design of the SKh (later designated An-2), and he quickly schemed a fighter to be powered by a single RD-10 (Soviet-made Junkers Jumo 004B) above the fuselage. He tested a tunnel model, but on 6th April 1947 received an instruction from NKAP (the state commissariat for aviation industry) to design a fighter with two RD-10s. By this time he had recognized that jet engines not only made possible unconventional new configurations for fighters but might even demand them. He quickly roughed out the Masha, abbreviated as the 'M'. A A Batumov and V A Dominikovskiy were appointed chief designers, with I I Yegorychev in charge of construction. Design was virtually complete when in late 1947 the NKAP instructed OKB-153 to redesign the aircraft to use the RD-45, the Soviet-built copy of the Rolls-Royce Nene. Apart from the forward fuselage, the redesign was total. Following tunnel testing of models, and free-flight testing of the E-153 (which was used as both a detailed full-scale wooden mock-up and a towed glider), construction of the M prototype went ahead rapidly. In July 1948, when the prototype was almost ready, and Mark L Gallai was about to begin flight testing, the project was cancelled. The La, MiG and Yak jet fighters were thought sufficient. (In 1953 Antonov again schemed a jet fighter, this time a tailed delta powered by an AL-7F, but it remained on paper.)

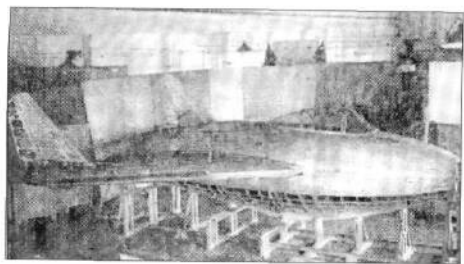
The original 1947 form of the Masha featured side inlets to the RD-10 engines buried in the thick central part of the wing. Outboard were



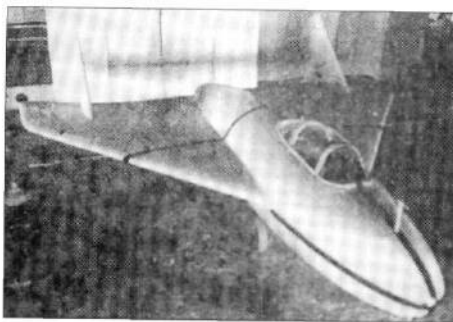
Model of the 1947 jet fighter project.

broad wings tapered on the leading edge with squared-off tips carrying swept fins and rudders. Beyond these were small forward-swept ailerons. The main wing had leading-edge flaps and aft spoilers. Having studied side doors to the cockpit, Antonov settled for a sliding canopy. Armament comprised two VYa-23 and two B-20. This armament remained unchanged in the M actually built, which had a single RD-45, rated at 2,270kg (5,000 lb) fed by cheek inlets. The wing was redesigned as a round-tipped delta, with the swept vertical tails positioned between two pairs of tabbed elevons.

Antonov considered that the final M ought to have been allowed to fly. He considered it would have dramatically outmanoeuvred any contemporary competition, and could later have had radar and a more powerful engine.



The E-153 glider.

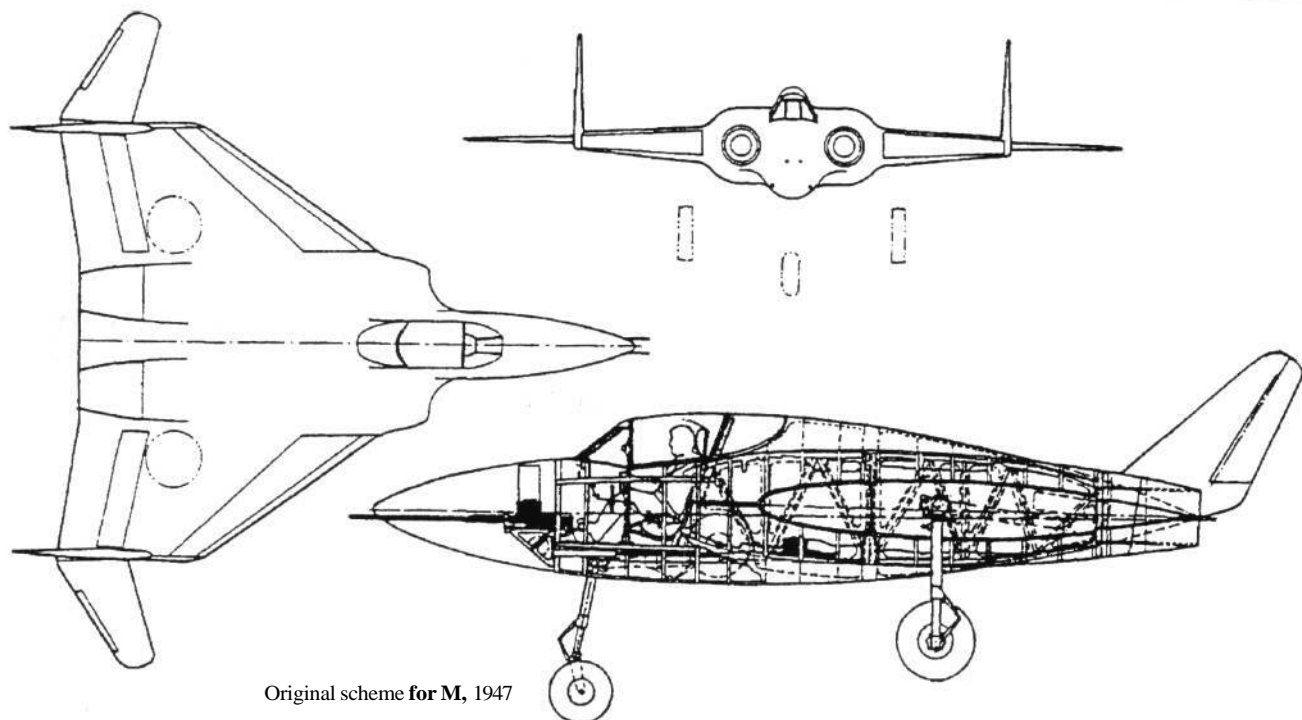


Dimensions (data 1947)

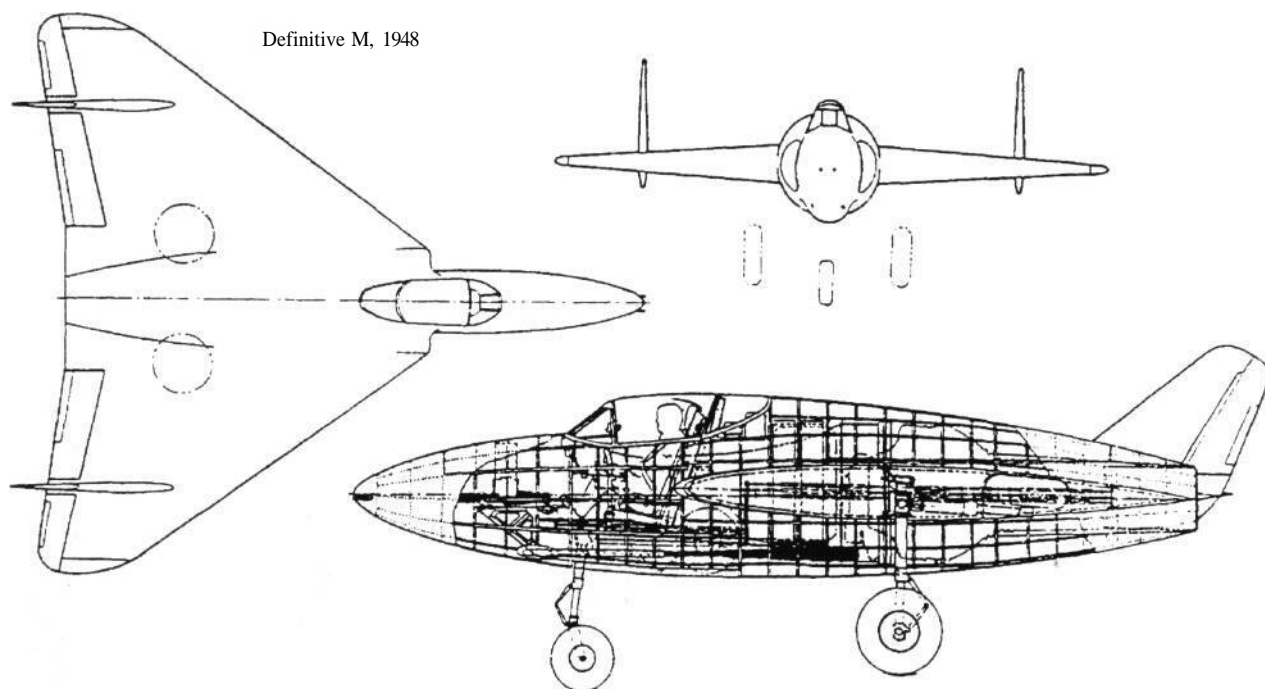
| | | |
|--------|-------|----------------|
| Span | 10.8m | 35 ft 5 in |
| Length | 10.6m | 34 ft 9 1/4 in |

Dimensions (data 1948)

| | | |
|----------------|--------|-----------------|
| Span | 9.3m | 30 ft 8 1/2 in |
| Length | 10.64m | 34 ft 10 1/2 in |
| No other data. | | |



Original scheme for M, 1947



Definitive M, 1948

Antonov 181

Purpose: To explore the Custer channel-wing concept.

Design Bureau: Oleg K Antonov, Kiev, Ukraine.

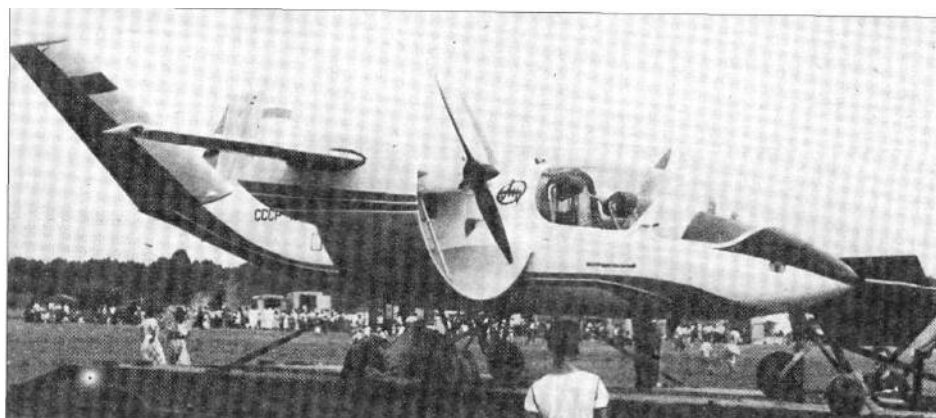
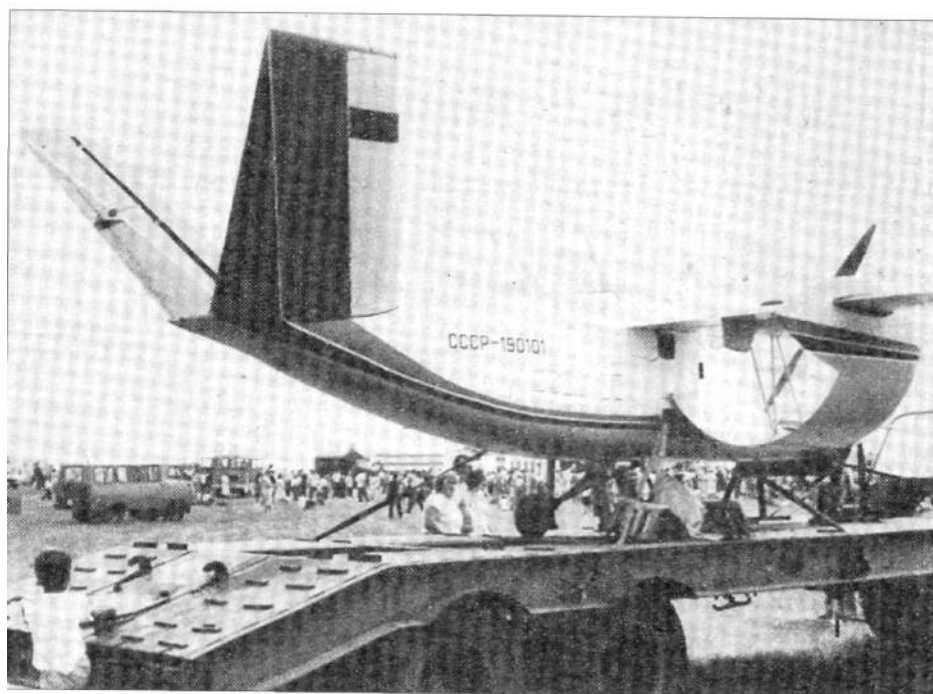
Little is known about this research aircraft, other than what could be gleaned by walking round it on 18th August 1990 and reading the accompanying placard. Its one public outing was on Soviet Day of Aviation, and the venue the airfield at the village of Gastomel, near Kiev. The configuration was instantly recognisable as being that of the 'channel-wing' aircraft proposed by American **W R** Custer in the mid-1950s. The key factor of this concept was powered lift gained by confining the propeller slipstream in a 180° half-barrel of aerofoil profile. Custer claimed the ability to take off and climb almost vertically, or to hover, whilst retaining full forward speed capability. Resurrecting the Custer concept was astonishing, as the claims for the channel-wing aircraft were soon shown to be nonsense, and instead of 1958 being the start of mass-production of the CCW-5 series version the whole thing faded from view. It was thus totally unexpected when the '181' appeared at an Open Day hosted by the Antonov OKB. It was not just parked on the grass but tied down on a trailer. Visitors were able to climb on to this and study the aircraft intimately, but there was nobody to answer questions.

The '181' was dominated by its two Custer-inspired channel wings, with aerofoil lifting surfaces curved round under the propellers so that they were washed by the slipstream. Whereas the Custer CCW-5 had pusher propellers above the trailing edge, the Antonov aircraft had tractor propellers above the leading edge. They were driven via shafts and gears by a 210hp Czech M-337A six-cylinder aircooled piston engine. Apart from this the aircraft appeared conventional, though the tail was of 'butterfly' configuration to keep it out of the slipstream, and of exceptional size in order to remain effective at very low airspeeds. Beyond the channel wings were small outer wings with ailerons. The nose was fighter-like, with a large canopy over the side-by-side cockpit, and the tricycle landing gear was fixed. The nose carried a long instrumentation boom, and there was a dorsal antenna, presumably for telemetry. The whole aircraft was beautifully finished, and painted in house colours with the Antonov logo. It bore Soviet flags on the fins, and civil registration SSSR-190101.

Construction of this research aircraft must have been preceded by testing of models. These must have given encouraging results, which were not reproduced in the '181'. Co-author Gunston asked Antonov leaders about the '181' and was told that it had been a serious project, but perhaps ought not to have been put on view.

| | | |
|-----------------------------|-------------------|-------------------|
| Dimensions | | |
| Span | 7.3m | 23 ft 7 in |
| Length | 7.31m | 23 ft 11 in |
| Wing area (total projected) | 7.0m ² | 75ft ² |
| Weights | | |
| Weight loaded (normal) | 820kg | 1,808lb |
| (maximum) | 900kg | 1,984lb |
| Performance | | |
| Maximum speed (placard) | 820 km/h | 510 mph |
| Range (placard) | 750km | 466 miles |

Three photographs of the An-181



Arkhangelskiy BSh/M-V

Purpose: To destroy enemy armour.

Design Bureau: A A Arkhangelskiy (Tupolev aide), with G M Mozharovskiy and IV Venevidov, Factory No 32, Moscow.

The idea was that of Mozharovskiy-Venevidov, who called their project the Kombain (combine) because of its versatility. They were long-time specialists in aircraft armament, among other things being responsible for all the early gun turrets in the Soviet Union. Arkhangelskiy increased their political power and got them a separate design office and factory for what became called the BSh (armoured assaulter, the same designation as the Ilyushin Stormovik) and also KABV (combined artillery-bomber weapon). The eskiznyi proekt (sketch project) was submitted on 29th December 1940, long-lead materials were sanctioned on 25th January 1941 and the project was confirmed at the NII-WS by AIFilin on 12th March 1941. Despite being (on paper) superior, it was terminated in the evacuation of the designers from Moscow to Kirov later in 1941, all effort being put into the Ilyushin aircraft (which was built in greater numbers than any other aircraft in history).

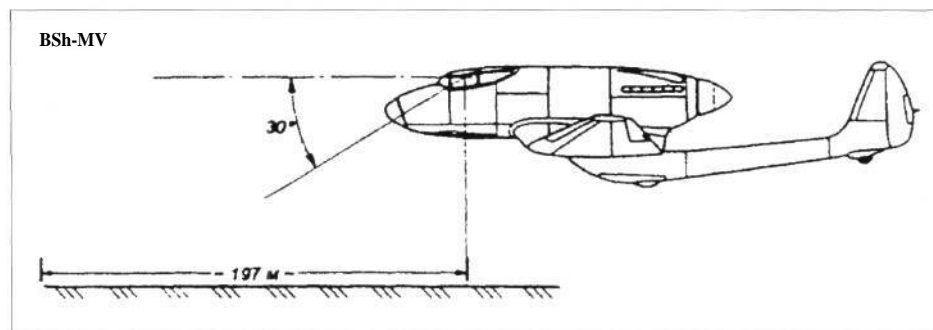
The whole emphasis in the M-V project was giving the pilot (the only occupant) the best possible view ahead over the nose. Whereas

the engine of the IL-2 Sturmovik blocked off the view at a downwards angle of 8°, the M-V aircraft gave the pilot a downwards view of 30°. This is because the engine (the 1,625hp AM-38, the same as the IL-2) was behind the cockpit. The tail was carried on twin booms and the landing gear was of the then-novel nosewheel type. Many armament schemes were planned, including one Taubin 23mm gun and four ShKAS, or four ShVAK, all mounted on pivots to fire diagonally down. Up to 500kg of bombs could also be carried, mainly to comprise AO-20 or AO-25 fragmentation bomblets.

On the basis of written evidence this aircraft would have been a better tank killer than the Ilyushin machine. The drawback was that

when the Ilyushin suffered heavy attrition from German fighters a backseater was put in to defend it, and this would have been difficult with the BSh/M-V.

| | | |
|-----------------------------|--------------------|----------------------|
| Dimensions | | |
| Span | 14m | 45 ft 11 in |
| Length | 11.26m | 36 ft 11 in |
| Wing area | 27.0m ² | 290.6ft ² |
| Weights | | |
| Empty | 3,689kg | 8,133lb |
| Maximum loaded | 5,130kg | 11,310 lb |
| Performance | | |
| Maximum speed | 532 km/h | 331 mph |
| Time to climb to 1, 3, 5 km | 4.8, 9.7, 19.2 min | |
| Minimum landing speed | 120 km/h | 74.6 mph |



Bartini Stal'-6, EI, and StaP 8

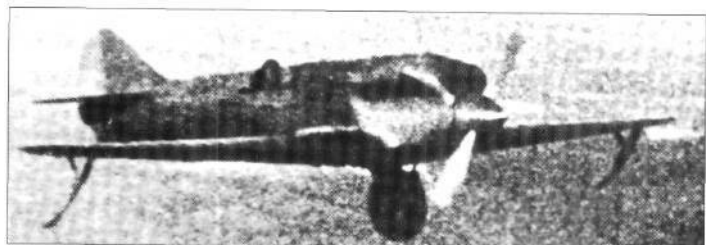
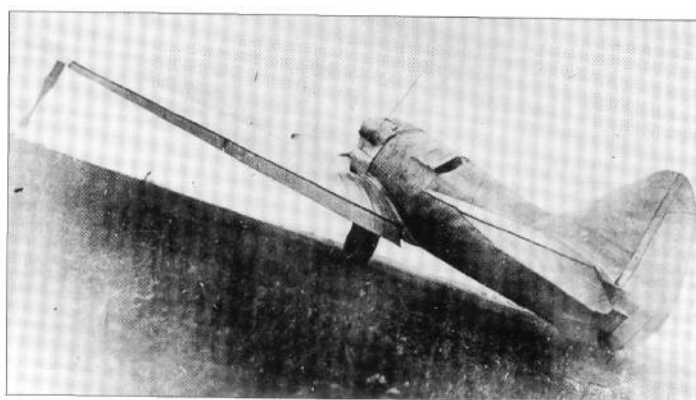
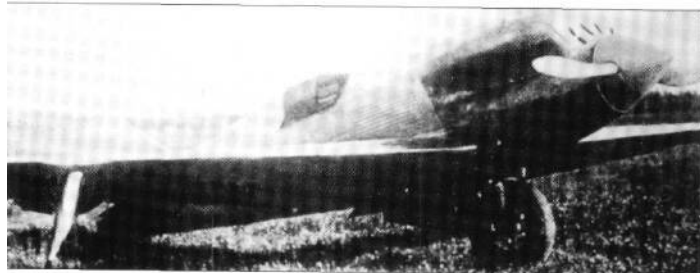
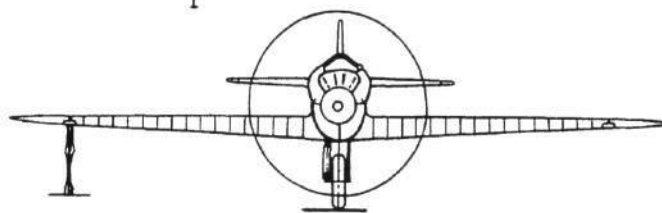
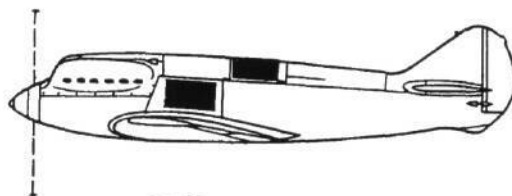
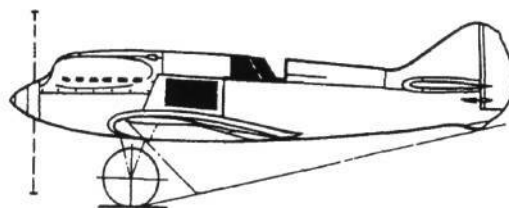
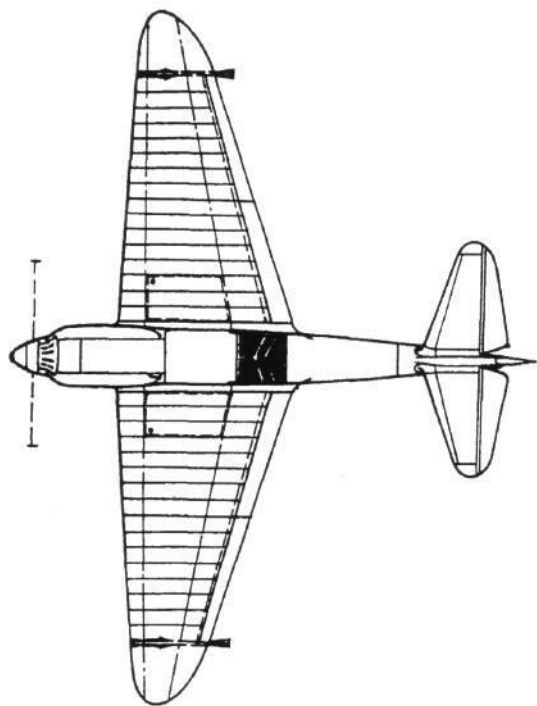
Purpose: High-speed research aircraft with fighter-like possibilities.

Design Bureau: SNII, at Factory No 240.

One of the few aircraft designers to emigrate to (not from) the infant Soviet Union was Roberto Lodovico Bartini. A fervent Communist, he chose to leave his native Italy in 1923 when the party was proscribed by Mussolini. By 1930 he was an experienced aircraft designer, and qualified pilot, working at the Central Construction Bureau. In April of that year he proposed the creation of the fastest aircraft possible. In the USSR he had always suffered from being 'foreign', even though he had taken Soviet citizenship, and nothing was done for 18 months until he managed to enlist the help of P I Baranov, head of the RKKA (Red Army) and M N Tukhachevskii (head of RKKA armament). They went to Y Y Anvel't, a deputy head at the GUGVF (main directorate of civil aviation), who got Bartini established at the SNII (GVF scientific test institute). Work began here in 1932, the aircraft being designated Stal' (steel) 6, as one of a series of ex-

perimental aircraft with extensive use of high-tensile steels in their airframes. After successful design and construction the Stal'-6 was scheduled for pre-flight testing (taxi runs at increasing speed) in the hands of test pilot Andrei Borisovich Yumashev. On the very first run he 'sensed the lightness of the controls.. which virtually begged to be airborne'. He pulled slightly back on the stick and the aircraft took off, long before its scheduled date. The awesomely advanced aircraft proved to be straightforward to fly, but the engine cooling system suffered a mechanical fault and the first landing was in a cloud of steam. Yumashev was reprimanded by Bartini for not adhering to the programme, but testing continued. Yumashev soon became the first pilot in the USSR to exceed 400km/h, and a few days later a maximum-speed run confirmed 420km/h (261 mph), a national speed record. One of Bartini's few friends in high places was Georgei K Ordzhonikidze, People's Commissar for Heavy Industries. In November 1933, soon after the Stal'-6 (by this time called the EI, experimental fighter) had

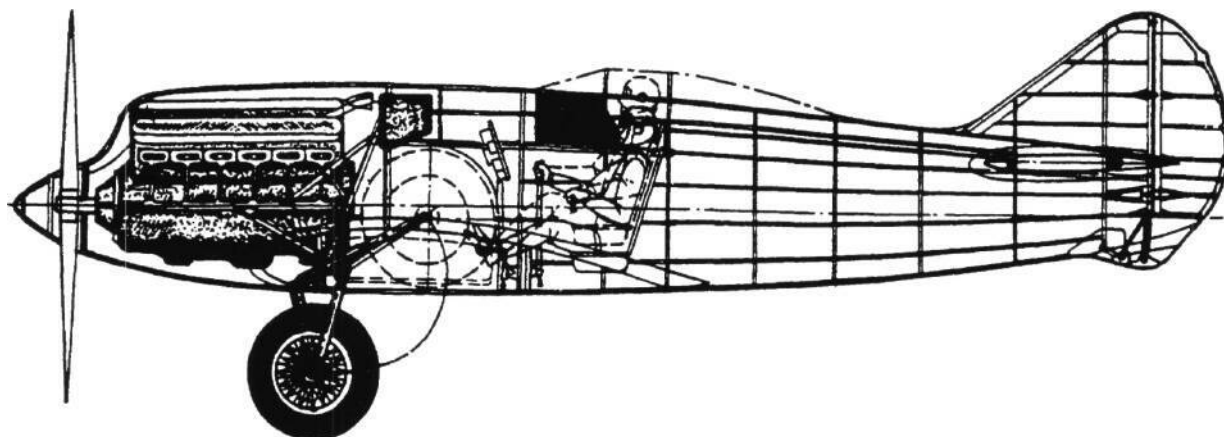
shown what it could do, he personally ordered Bartini to proceed with a fighter derived from it. This, the Stal'-8, was quickly created in a separate workshop at Factory 240, and was thus allocated the Service designation of I-240. Hearing about the Stal'-6's speed, Tukhachevskii called a meeting at the Main Naval Directorate which was attended by many high-ranking officers, including heads from GUAP (Main Directorate of Aviation Production), the WS (air force), RKKA and SNII GVF. The meeting was presided over by Klementi Voroshilov (People's Commissar for Army and Navy) and Ordzhonikidze. At this time the fastest WS fighter, the I-5, reached 280km/h. The consensus of the meeting was that 400km/h was impossible. Many engineers, including A A Mikulin, designer of the most powerful Soviet engines, demonstrated or proved that such a speed was not possible. When confronted by the Stal'-6 test results, and Comrade Bartini himself, the experts were amazed. They called for State Acceptance tests (not previously required on experimental aircraft). These began



Top: Stal'-6.

Centre: Three views of the StaP-6.

Bottom: Inboard profile of Stal'-6.



in the hands of Pyotr M Stefanovskii on 8th June 1934 (by which time the fast I-16 monoplane fighter was flying, reaching 359km/h). On 17th June the Stal'-6 was handed to the Nil WS (air force scientific research institute), where it was thoroughly tested by Stefanovskii and N V Ablyazovskiy. They did not exceed 365km/h, because they found that at higher speeds they needed to exert considerable strength to prevent the aircraft from rolling to port (an easily cured fault). On 13th July the landing-gear indicator lights became faulty and, misled, Stefanovskii landed with the main wheel retracted. The aircraft was repaired, and the rolling tendency cured. Various modifications were made to make the speedy machine more practical as a fighter. For example the windscreen was fastened in the up position and the pilot's seat in the raised position. After various refinements Stefanovskii not only achieved 420km/h but expressed his belief that with a properly tuned engine a speed 25-30km/h higher than this might be reached. The result was that fighter designers - Grigorovich, Polikarpov, Sukhoi and even Bartini himself - were instructed to build fighters much faster than any seen hitherto. Bartini continued working on the StaP-8, a larger and more practical machine than the Stal'-6, with an enclosed cockpit with a forward-sliding hood, two ShKAS machine guns and an advanced stressed-skin airframe. The engine was to be the 860hp Hispano-Suiza HS12Ybrs, with which a speed of 630km/h (391 mph) was calculated. Funds were allocated, the Service designation of the Stal'-8 being I-240. This futuristic fighter might have been a valuable addition to the WS, but Bartini's origins were still remembered even in the mid-1930s, and someone managed to get funding for the Stal'-8 withdrawn. One reason put forward was vulnerability of the steam cooling system. In May 1934 the I-240 was abandoned, with the prototype about 60 per cent complete.

Everything possible was done to reduce drag. The cantilever wing had straight taper and slight dihedral (existing drawings incorrectly show a horizontal upper surface). The two spars were made from KhMA (chrome-molybdenum steel) tubes, each spar comprising seven tubes of 16.5mm diameter at the root, tapering to three at mid-semi-span and ending as a single tube of 18mm diameter towards the tip. The ribs were assembled from Enerzh-6 (stainless) rolled strip. Ailerons, flaps and tail surfaces were assembled from steel pressings, with Percal fabric skin. The flaps were driven manually, and when they were lowered the ailerons drooped 5°. Bartini invented an aileron linkage which adjusted stick force according to indicated airspeed (this was resurrected ten years later by the Central Aero-Hydrodynamic Institute as their

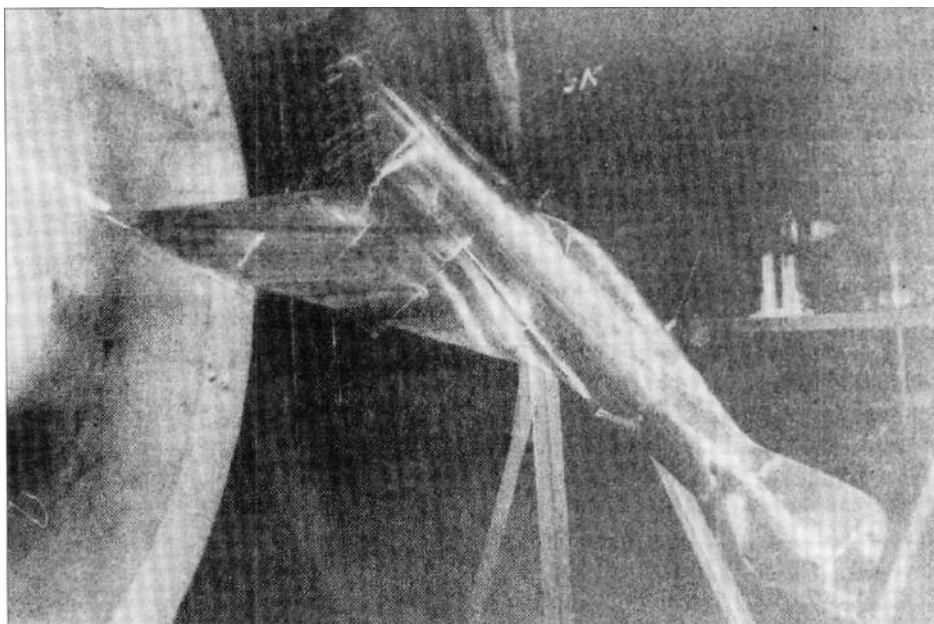
own idea). The fuselage was likewise based on a framework of welded KhMA steel tubes. Ahead of the cockpit the covering comprised unstressed panels of magnesium alloy, the aft section being moulded plywood. In flight the cockpit was part-covered by a glazed hood flush with the top of the fuselage, giving the pilot a view to each side only. For take-off and landing the hood could be hinged upwards, while the seat was raised by a winch and cable mechanism. Likewise the landing gear was based on a single wheel on the centre-line, with an 800 x 200mm tyre, mounted on two struts with rubber springing. The pilot could unlock this and raise it into an AMTs (light alloy) box between the rudder pedals. For some reason the fuselage skin on each side of this bay was corrugated. The wheel bay was normally enclosed by a door which during the retraction cycle was first opened to admit the wheel and then closed. Extension was by free-fall, finally assisted by the cable until the unit locked. Under the outer wings were hinged support struts, likewise retracted to the rear by cable. When extended, each strut could rotate back on its pivot against a spring. Under the tail was a skid with a rubber shock absorber. The engine was an imported Curtiss Conqueror V-1570 rated at 630hp, driving a two-blade metal propeller with a large spinner (photographs show that at least two different propellers were fitted). This massive vee-12 engine was normally water-cooled, but Bartini boldly adopted a surface-evaporation steam cooling system. The water in the engine was allowed to boil, and the steam flowed into the leading edges of the wings which were covered by a double skin from the root to the aileron. Each leading edge was electrically spot- and seam-welded, with a soldering agent, to form a sealed box with a combined internal area of 12.37m² (133ft²).

Each leading edge was attached to the upper and lower front tubes of the front spar. Inside, the steam, under slight pressure, condensed back into water which was then pumped back to the engine. The system was not designed for prolonged running, and certainly not with the aircraft parked.

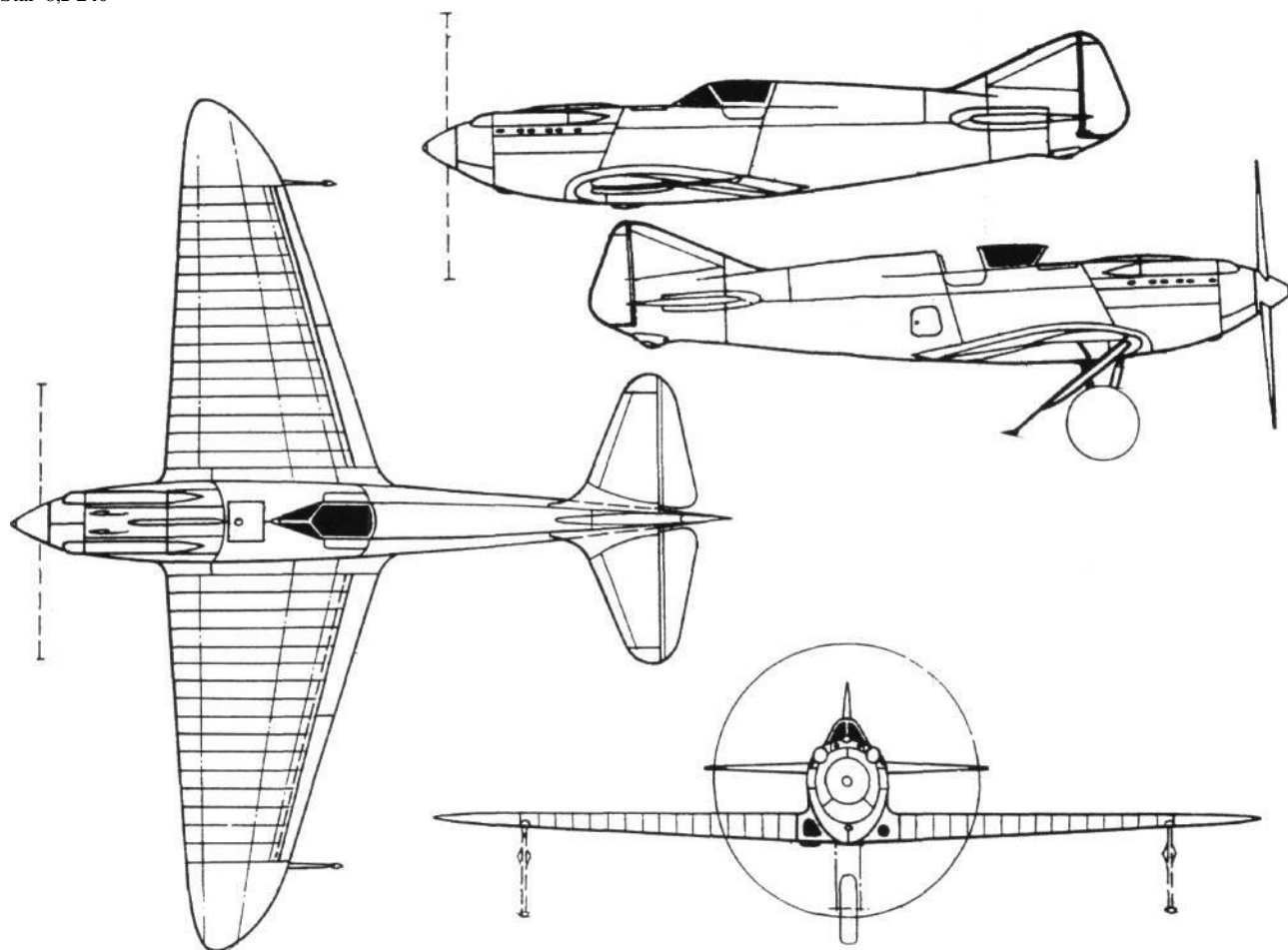
Bartini succeeded brilliantly in constructing the fastest aircraft built at that time in the Soviet Union. At the same time he knew perfectly well that the Stal'-6 was in no way a practical machine for the WS. The unconventional landing gear appeared to work well, and even the evaporative cooling system was to be perpetuated in the I-240 fighter (but that was before the Stal'-6 had flown). Whether the I-240 would have succeeded in front-line service is doubtful, but it was the height of folly to cancel it. The following data refers to the Stal'-6.

| | | |
|-----------------------|--------------------|--------------------|
| Dimensions | | |
| Span | 9.46m | 31 ft 1 in |
| Length | 6.88m | 22 ft 6 in |
| Wing area | 14.3m ² | 154ft ² |
| Weights | | |
| Empty | 850kg | 1,874 lb |
| Maximum loaded weight | 1,080kg | 2,381 lb |
| Performance | | |
| Maximum speed | 420km/h | 261 mph |
| Maximum rate of climb | 21m/s | 4,135ft/min |
| Service ceiling | 8,000 m | 26,250ft |
| Endurance | 1 hour 30 min | |
| Minimum landing speed | 110km/h | 68.4 mph |

Stal'-8 model in tunnel.



Stal'-8, I-240



Bartini Stal'-7

Purpose: Originally, fast passenger transport; later, long-range experimental aircraft.

Design: SNII GVF; construction at GAZ (Factory) No 81, Moscow Tushino.

In the winter 1933-34 the GUGVF (chief administration of the civil air fleet) issued a requirement for a fast transport aircraft to carry 10 to 12 passengers. Curiously, the two prototypes built to meet this demand were both the work of immigrant designers, the Frenchman Laville (with ZIG-1) and the Italian Bartini. The latter had already produced drawings for a transport to cruise at 400km/h (248mph), which was well in advance of what the GVF had in mind. Always captivated by speed, Stalin decreed that a bomber version should be designed in parallel. Still in charge of design at the SNII GVF, Bartini refined his study into the Stal'-7, the name reflecting its steel construction.

Strongly influenced by the Stalin decree, Bartini created a transport notable for its cramped and inconvenient fuselage, highly

unsuitable for passengers but excellent for bombs, and for long-range flight. The original structure was to be typical Bartini welded steel-tube trusses with fabric covering, but the stress calculations were impossibly difficult, with 200 primary rigid welded intersections between tubes of different diameters. In late 1934 the fuselage was redesigned as a light-alloy stressed-skin structure, with simpler connections to the unchanged wing.

Only one aircraft was built, in the workshops of ZOK, the factory for GVF experimental construction. The first flight was made on an unrecorded date in autumn 1936, the pilot being N P Shebanov. Performance was outstanding, and Shebanov proposed attempting a round-the-world flight. In 1937 the StaP-7 was fitted with 27 fuel tanks with a total capacity of 7,400 litres (1,628 Imperial gallons, 1,955 US gallons). A maximum-range flight was then attempted, but - possibly because of structural failure of a landing gear - the aircraft crashed on take-off. Bartini was arrested, and was in detention (but still designing, initially at OKB-4, Omsk) for 17 years.

The aircraft was repaired, and on 28th August 1939, at a slightly reduced weight, successfully made a closed-circuit flight of 5,068km (3,149 miles) in 12hrs 51min (average speed 404.936km/h, 251.62mph), to set an FAI Class record. The route was Moscow Tushino-Maloe Brusinskoe (Sverdlovsk region)-Sevastopol-Tushino, and the crew comprised Shebanov, copilot V A Matveyev and radio/navigator N A Baikuzov. In Bartini's absence, the project was seized by his opportunist co-worker V G Yermolayev, who redesigned it into the outstanding DB-240 and Yer-2 long-range bomber.

The wing was typical Bartini, with pronounced straight taper and construction from complex spars built up from multiple steel tubes, almost wholly with fabric covering. Each wing comprised a very large centre section, with depth almost as great as that of the fuselage, terminating just beyond the engine nacelles 2.8m (9ft 2/4in) from the centreline, with sharp anhedral, and thinner outer panels with dihedral. The trailing edges carried split flaps and Frise ailerons, the left aileron having

a trim tab. One account says that the inverted-gull shape 'improved stability and provided a cushion effect which reduced take-off and landing distance', but its only real effect was to raise the wing on the centreline from the low to the mid position.

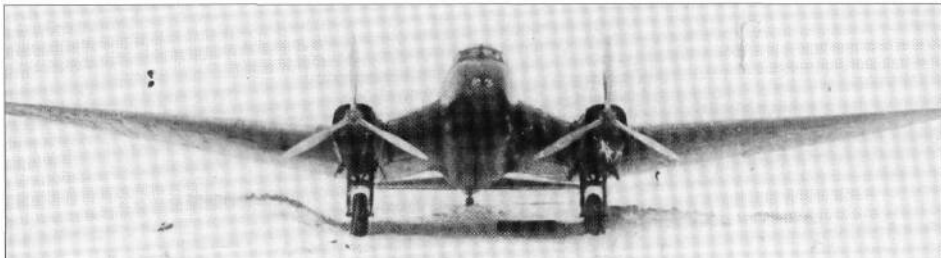
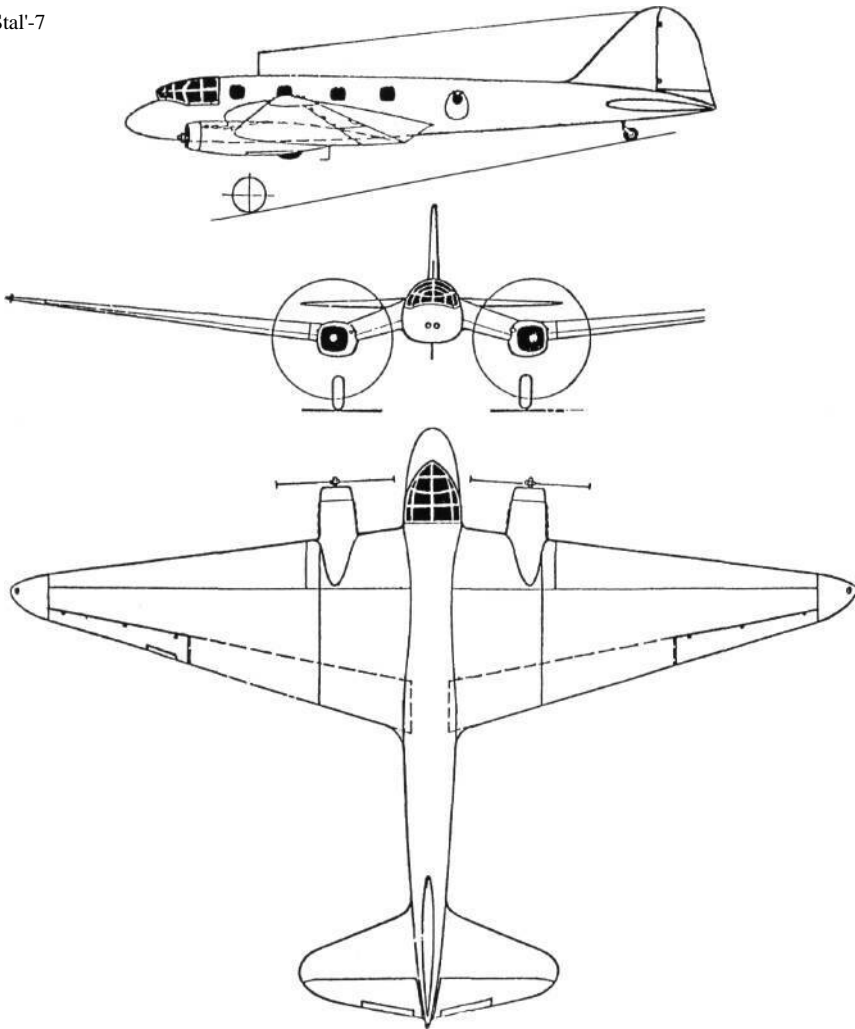
This was just what the fuselage did not need, because the massive deep spars formed almost impassable obstructions and eliminated any possibility of using the aircraft as a passenger airliner. The fuselage was a light-alloy structure, with an extremely

cramped cross-section with sides sloping in towards the top (almost a round-cornered triangle). Entry was via a very small door on the left of the rear fuselage. The cockpit in the nose seated pilots side by side, and had a glazed canopy with sliding side windows and the then-fashionable forward-raked windscreen. Immediately behind the cockpit there was a station for the navigator/radio operator. The tail surfaces, made of dural/fabric, were of low aspect ratio, the elevators having tabs.

The engines were the 760hp M-100, these being the initial Soviet licence-built version derived by V Ya Klimov from the Hispano-Suiza 12Ybrs. They were installed in neat cowlings at the outer ends of the centre section, angled slightly outwards and driving propellers with three metal blades which could have pitch adjusted on the ground. One account states that wing-surface radiators were used, but it is obvious from photographs that ordinary frontal radiators were fitted, as in the Tupolev SB bomber. Plain exhaust stubs were fitted, though this may have scorched the wing fabric and one drawing shows exhaust pipes discharging above the wing. In the course of 1938-39 the original engines were replaced by the derived M-103, rated at 860hp, which improved performance with heavy fuel loads. A hydraulic system was provided to operate the flaps and the fully retractable main landing gears, each unit of which had a strong pair of main legs which hinged at mid-length, the unit then swinging back on twin forward radius arms (like a DC-3 back-to-front). The castoring tailwheel was fixed. In the nose were twin landing lights.

The Stal'-7 was simply a sound aeroplane able to fly at what was in its day a very long way at high speed. As a transport it was inconvenient to the point of being useless, though it was supposed to be able to seat 12 passengers, and it was flawed by its basic layout and structure. The Soviet Union was right to take a licence for the Douglas DC-3. On the other hand, Yermolayev transformed the Stal'-7 into an outstanding long-range bomber.

Stal'-7



| Dimensions | | |
|--------------------------------|---------------------|---------------------------------------|
| Span | 23.0 m | 75ft 5 ¹ / ₂ in |
| Length | 16.0m | 52 ft 6 in |
| Wing area | 72.0 m ² | 775ft ² |
| Weights | | |
| Empty | 4,800 kg | 10,580 lb |
| Loaded (originally) | 7,200 kg | 15,873 lb |
| Maximum loaded (1939) | 11,000 kg | 24,250 lb |
| Performance | | |
| Max speed at 3,000m (9,842 ft) | 450km/h | 280 mph |
| Cruising speed | 360/380 km/h | 224/236 mph |
| Service ceiling | | |
| (disbelieved by Gunston) | 11,000 m | 36,090ft |
| (on one engine, light weight) | 4,500 m | 14,764ft |

Left: Two views of Stal'-7.

BartiniWA-14

Purpose: To explore the characteristics of a vehicle able to fly as an aeroplane or skim the ocean surface as an Ekranoplan (literally 'screen plan', a device covering an area with a screen).

Design Bureau: TANTK named for G M Beriev Taganrog.

Ever one to consider radical solutions, Bartini spent part of 1959 scheming a giant marine vehicle called M. Seaborne at rest, this was to be able to rise from the water and fly at high speed over long distances. It was to make true flights at high altitude, but also have the capability of 'flying' just above the sea surface. Such a vehicle was initially seen as urgently needed to destroy US Navy Polaris-missile submarines, but it could have many other applications. The idea was refined into one called 2500, from its weight in tonnes, and ultimately designated M-62 or MVA-62.

TANTK Beriev investigated stability, control and performance of the proposed configuration with the small Be-1. This looked vaguely like a jet fighter, with a front cockpit, large centropplan (central wing) with a turbojet on top, twin floats, outer wings and twin fins and rudders. Under each float was a surface-piercing V-type hydrofoil, which was not to be a feature of the full-scale vehicle.

Pending funding for this monster, TANTK Beriev were ordered to build three WA-14 prototypes, this being a practical basis for a multirole vehicle. Missions were to include sea/air search and rescue, defence against all kinds of hostile submarines and surface warships, and patrol around the Soviet coastlines. Production craft were to be kept at readiness on coastal airfields. The vehicle was classed as an amphibious aircraft. It was to be developed in three phases. The WA-14M1 was to be an aerodynamics and technology test-bed, initially with rigid pontoons on the ends of the centropplan, and later with these replaced by PVPU inflatable pontoons (which took years to develop). The WA-14M2 was to be more advanced, with two extra main engines to blast under the centropplan to give lift and later with a battery of lift engines to give VTOL capability, and with fly-by-wire flight controls. The third stage would see the VTOL vehicle fully equipped with armament and with the Burevestnik computerised ASW (anti-submarine warfare) system, Bor-1 MAD (magnetic anomaly detection) and other operational equipment.

Following very extensive research, and tests with simulators, the first vehicle, No19172, was completed as an aeroplane. It was tested at the Taganrog WS flying school, which had a concrete runway. Accompanied

by numerous engineers, including deputy chief designer Nikolai A Pogorelov, the test crew of Yu M Kupriyanov and navigator/systems engineer L F Kuznetsov opened the flight test programme with a conventional take-off on 4th September 1972. The only problem was serious vibration of hydraulic pipes, which resulted in total loss of fluid from one of the two systems.

In 1974 the PVPU inflatable pontoons were at last installed, though their expansion and retraction caused many problems. Flotation and water taxi tests followed, culminating in the start of flight testing of the amphibious aircraft on 11th June 1975. Everyone was amazed that Bartini was proved correct in his belief that the rubber/fabric pontoons would retain their shape at high airspeeds. On water they were limited to 36km/h, so later they were replaced by rigid pontoons, with skegs (axial strakes). The forward fuselage was lengthened and the starting (cushion-blowing) engines added. On the debit side, Bartini was also right in predicting that the Lotarev bureau would never deliver the intended battery of 12 RD-36-35PR lift engines, and this made the second and third prototypes redundant.

Bartini died in 1974, and the now truncated programme continued with trickle funding. The blowing engines caused resonance which resulted in breakage of landing-gear doors and buffeting of the rear control flaps. The vehicle never flew again, but did carry out manoeuvre tests on water with reversers added to the blowing engines. TANTK was given higher-priority work with the A-40, A-50 and IL-78.

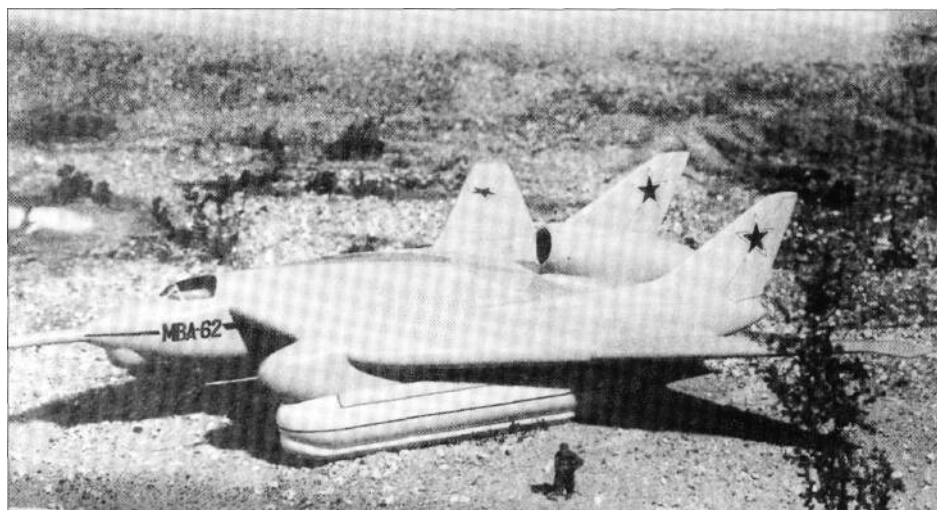
The entire structure was marinised light alloy, much of the external skin being of honeycomb sandwich. The airframe was based on the fuselage, centropplan of short span but

very long chord, and cigar-like floats carrying the tails. Above the rear on the centreline were the two main engines. The starting engines were mounted on the sides of the nose, and the (unused) lift-engine bay was disposed around the centre of gravity amidships. On each side of this area projected the outer wings, with straight equal taper and thickness/chord ratio of 12 per cent, with full-span leading-edge slats, ailerons and flaps hinged 1m (3ft 3 1/2in) below the wing.

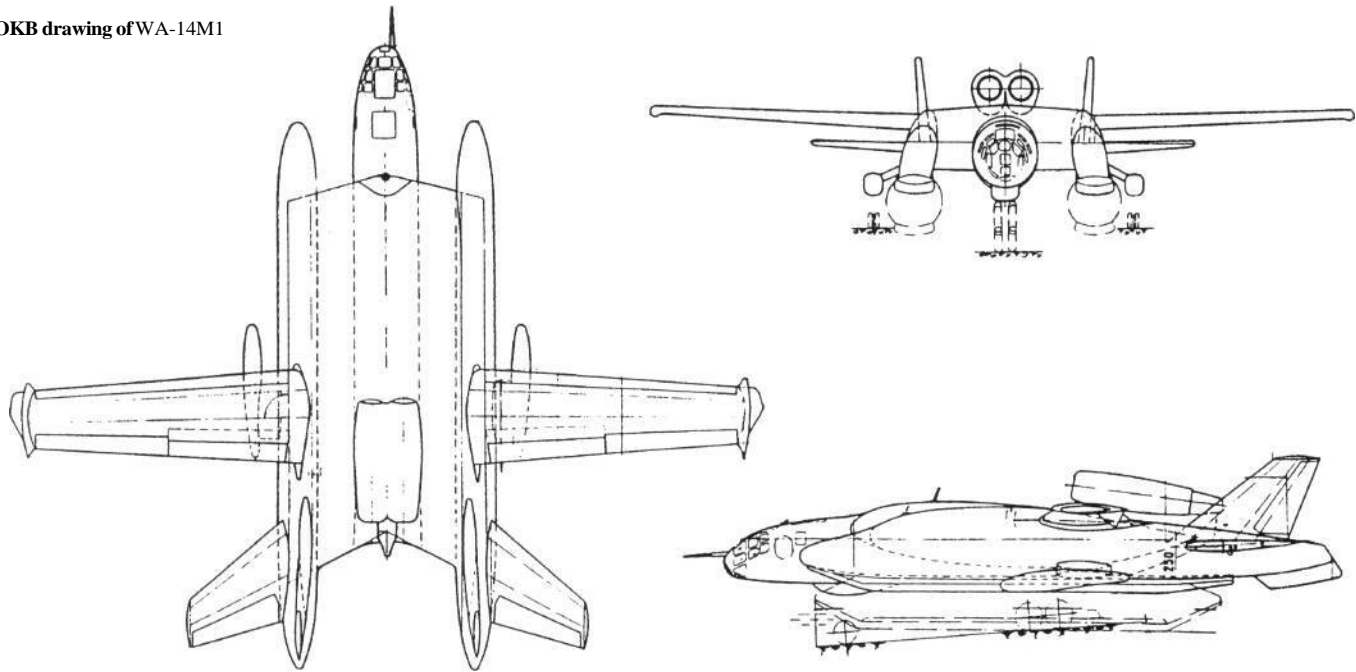
The propulsion and starting (cushion-blowing) engines were all Solov'yov D-30M turbofans, each rated at 6,800kg (14,991 lb). The starting engines were equipped with cascade-type thrust deflectors, and later with clamshell-type reversers. A TA-6AAPU (auxiliary power unit) was carried to provide electric power and pneumatic power. Bleed air served the cabin conditioning system and hot-air deicing of all leading edges. A total of 15,500kg (34,171 lb) of fuel was housed in two metal tanks and 12 soft cells.

The cockpit contained three K-36L ejection-seats, for the pilot, navigator and weapon-systems operator. Flight controls were linked through the SAU-M autopilot and complex military navigation and weapon-delivery systems. Had the aircraft undertaken VTOL flights the reaction-control system would have come into use, with six pairs of high-power bleed-air nozzles disposed at the wingtips and longitudinal extremities. For operation from land No 19172 was fitted with the nose and a single main landing gear of a Tu-22, both on the centreline, and the complete outrigger-gear pods of a Myasishchev 3M heavy bomber. Maximum ordnance load, carried on IL-38 racks, comprised 4 tonnes (8,818 lb), made up of AT-1 or -2 torpedoes, PLAB-250-120 or other bombs, various mines up to UDM-1500 size, RYu-2 depth charges and various sonobuoys (such as 144 RGB-1U).

Model of MVA-62.



OKB drawing of WA-14M1

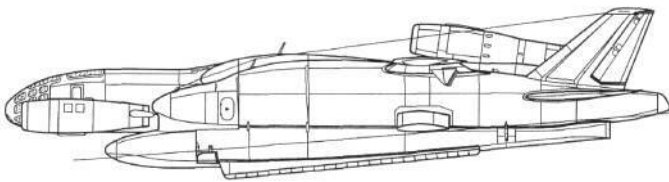
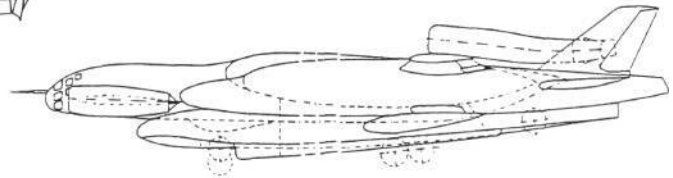
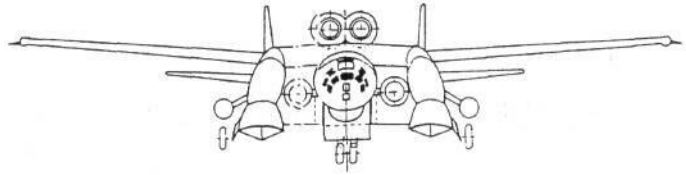
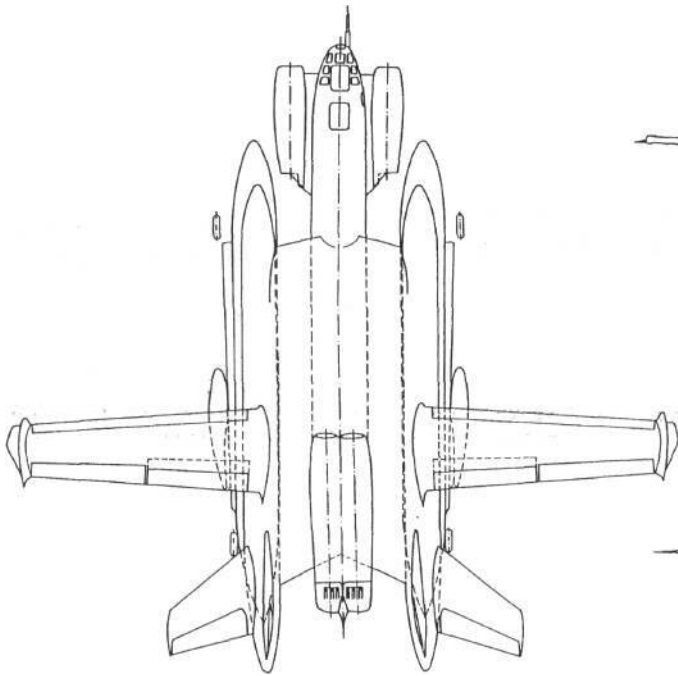


One of the incomplete WA-14s was damaged by fire, the third being abandoned at an early stage. The one with which all the flying was done, No19172, was retired to the Monino museum in a dismantled state, where it carries the number '10687' and 'Aeroflot'. TANTK had various projects for intended production amphibious derivatives. These were grouped under letter T, and two such are illustrated here for the first time.

The WA-14 was an outstandingly bold concept which very nearly came off. There is little doubt it could have led to a practical vehicle for many oceanic purposes. In the long term all it achieved was to give TANTK-Beriev considerable experience in many new disciplines, especially in challenging avionics and flight-control areas. Such a programme would have almost no chance of being funded today.

| Dimensions | | |
|---|-----------------------|-----------------------|
| Span (wing) | 28.5m | 93 ft 6 in |
| (over lateral-control pods) | 30.0 m | 98 ft 5 in |
| Length (as built, excluding PVD instrumentation boom) | 25.97 m | 85 ft 2 1/2 in |
| later | 30.0m | 98 ft 5 in |
| Wing area | 217.788m ² | 2,344ft ² |
| Total lifting area | 280 m ² | 3,014 ft ² |
| Weights | | |
| Empty (in final form) | 23,236 kg | 51,226 lb |
| (intended weight with lift jets) | 35,356 kg | 77,945 lb |
| Maximum take-off weight | 52,000kg | 114,638 lb |
| Performance | | |
| Max speed at 6,000m (19,685 ft) | 760km/h | 472 mph |
| Patrol speed (also minimum flight speed at low level) | 360 km/h | 224 mph |
| Service ceiling | 9,000-10,000m | 32,800 ft (max) |
| Practical range | 2,450 km | 1,522 miles |
| Patrol duration at a radius of 800 km (497 miles) | 2 hrs 15 min | |

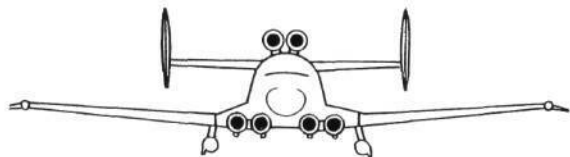
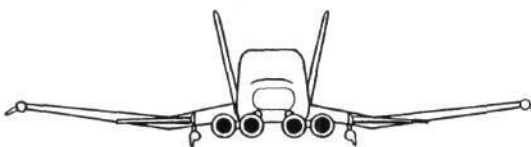
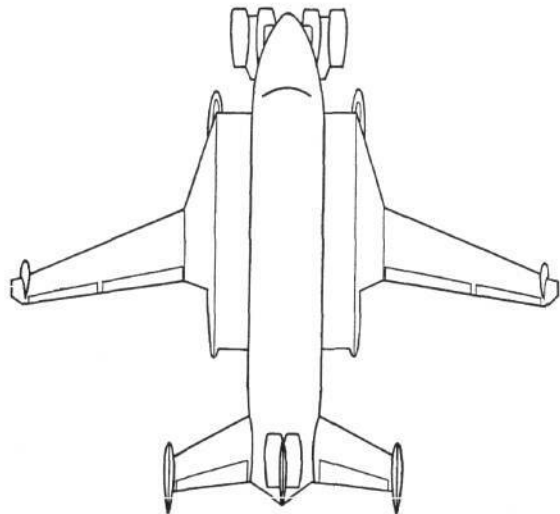
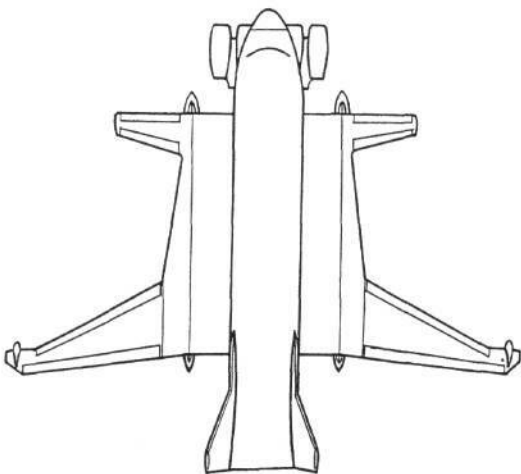
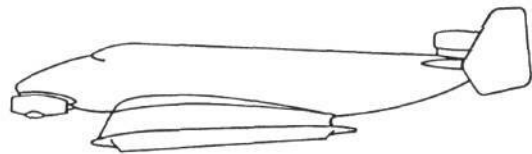
WA-14M1 on land (without pontoons), on water and in flight.



Above: Three-view of WA-14M2 **with** retractable landing gear.

Left: A **more** detailed side elevation of WA-14M2.

Below: **Two** of the 'T' projects.



Belyayev Babochka

Purpose: To test an experimental wing.

Design bureau: Kazan Aeronautical Institute, Kazan, Tatar ASSR.

The concept of the wing was that of V N Belyayev, but in order to test it he collaborated with VI Yukharin of the KAI. Partly because it would have been difficult to match centre of lift with centre of gravity by retrofitting the wing to an existing aircraft, it was decided to design an aircraft specially for this purpose. It was called Babochka (butterfly). The project was launched in 1937, and drawings were completed late the following year. Throughout, Belyayev was devoting most of his time to the EOI (see page 27). The single Babochka was being readied for flight when the Soviet Union was invaded. Even though Kazan was far to the East of Moscow, this project was not considered important and those working on it were drafted elsewhere.

This aircraft was essentially a straightforward low-wing monoplane, of fighter-like appearance, with a single (relatively large) piston engine. It is believed that the structure was almost all-metal stressed skin. The key item, the wing, had a high aspect ratio, swept-forward inboard sections and swept-back outer panels. The objective was to make a wing that was flexible yet which in severe positive manoeuvres would deflect upwards without causing a longitudinal pitch problem. Under load, the inner wings deflected upwards, tending to twist with positive angle of incidence, automatically countered by the negative twist of the outer panels. This was hoped to lead to an extension of Belyayev's concept of a wing that was inherently stable longitudinally.

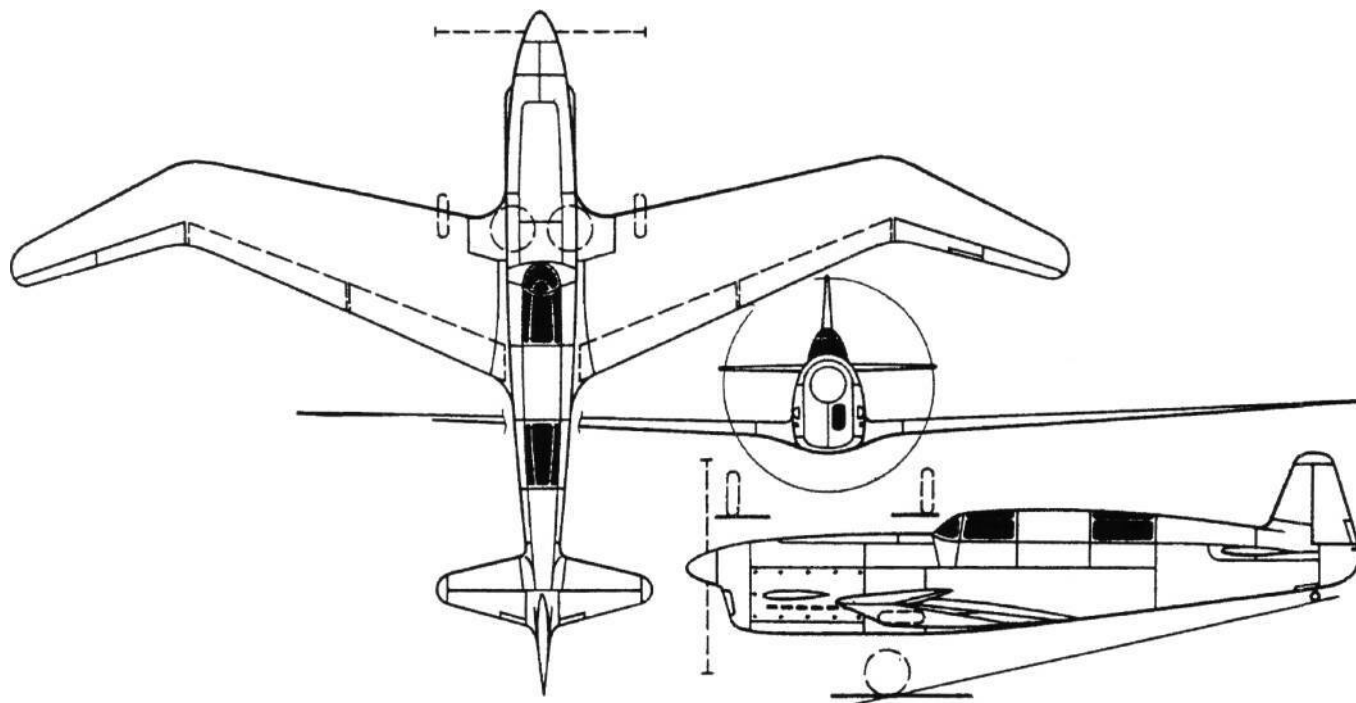
The inner wings were fitted with inboard and outboard split flaps, while the smaller outer panels carried two-section ailerons.

The engine was mounted on the nose on a steel-tube truss. According to historian V B Shavrov the engine was a 'Renault 430hp' (which would have had 12 cylinders and a central air-cooling inlet). In fact it must have been an MV-6, a licence-built Renault with six aircooled cylinders, rated at 210hp. Tandem enclosed cockpits were provided for the pilot and test observer. The tail, remarkably small (reflecting the designer's belief in the stability of the wing) positioned the horizontal tail wholly in front of the rudder. The landing gears were fully retractable, the main wheels folding inwards into the extended-chord wing roots.

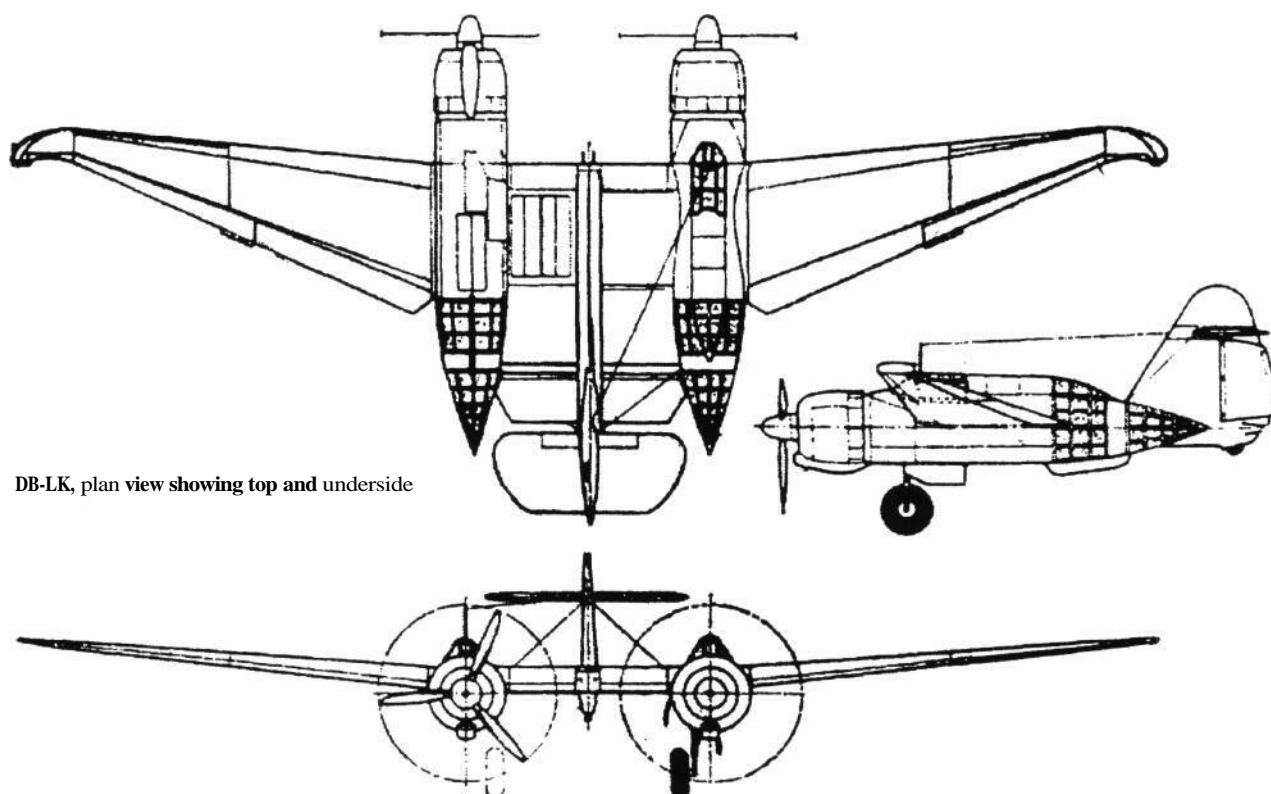
Though there is no reason to doubt that the Babochka would have flown successfully, there is equally no reason to believe that it would have shown any significant advantage over an aircraft with a conventional straight-tapered wing.



| Dimensions | | |
|-------------------------|--------------------|--------------------|
| Span | 10.8m | 35 ft 5 1/4 in |
| Length | 6.84m | 22 ft 5 1/4 in |
| Wing area | 11.5m ² | 124ft ² |
| Weights | | |
| Empty | 680kg | 1,499lb |
| Loaded | 1,028kg | 2,266lb |
| Performance (estimated) | | |
| Maximum speed | 510km/h | 317 mph |



Belyayev DB-LK



DB-LK, plan view showing top and underside

Purpose: The initials stood for 'long-range bomber, flying wing'.

Design Bureau: Designer's own brigade at the Central Aerodynamics and Hydrodynamics Institute.

Viktor Nikolayevich Belyayev, born in 1896, began his career as a stressman in the OMOS bureau in 1925. He subsequently worked in AGOS, KOSOS-CAH1 (TsAGI), the Tupolev OKB, AviAvnito and Aeroflot. He liked tailless aircraft, and had a fixation on a 'bat wing', with slight forward sweep and curved-back tips, which he considered not only gave such aircraft good longitudinal stability but also minimised induced drag. He tested such a wing in his BP-2 glider of 1933, which was towed by an R-5 from Koktebel (Crimea) to Moscow. In 1934 he entered an AviAvnito competition for a transport with a design having twin fuselages, each with a 750hp Wright Cyclone engine and ten passenger seats, but this was not built.

From this he derived the DB-LK bomber. Designed in 1938, the single prototype was completed in November 1939, but (according to unofficial reports) pilots declined to do more than make fast taxi runs, the aircraft being dubbed Kuritsa (chicken) in consequence. In early 1940 this unacceptable situ-

ation was ended by the appointment by GK Nil WS (direction of the air force scientific test institute) of M A Nyukhtikov as test pilot, assisted by lead engineer TTSamarin and test observer N I Shaurov. Test flying began in early 1940, at which time Mark Gallai also joined the test team. Nyukhtikov complained that the flight-control system was inadequate and that the landing-gear shock absorbers were weak. In the investigation that followed, the Commission agreed with the first point, but the Head of Nil WS, AI Filin, thought the landing gear satisfactory. He then changed his mind when a leg collapsed with himself at the controls (see photo). Later the main legs were not only redesigned but were also inclined forward, to improve directional stability on the ground and avoid dangerous swing.

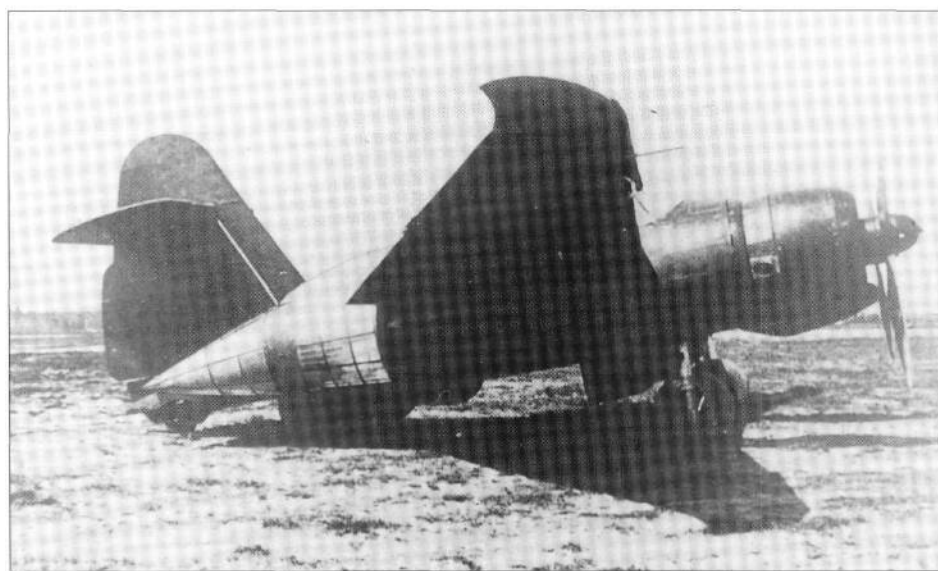
Later in 1940 the Nil WS ordered the DB-LK to be abandoned, despite its outstanding performance, and the planned imminent installation of 1,100hp M-88 engines. Belyayev had by this time designed a refined version with 1,700hp M-71 engines, but was told that the DB-3F (later redesignated IL-4) would remain the standard long-range bomber.

Belyayev left comprehensive aerodynamic details, showing that the strange wing was of CAH1 (TsAGI) *MV-6bis* profile over the long-chord centroplan (centre section) but Götting

gen 387 profile over the supposed 'bat-like' outer panels. Overall aspect ratio was no less than 8.2, and the outer wings had a leading-edge sweep of minus 5° 42', with a taper ratio of 7. The airframe was almost entirely a modern light-alloy stressed-skin structure, the wing having five spars. There is evidence the structural design was modern, with most components pressed or even machined from sheet. The outer wings had flaps of the unusual Zapp type, extended to 45°, with Frise ailerons outboard, which even had miniature sections on the back-raked tips. Ahead of the ailerons were slats.

At each end of the centroplan was a fuselage, of basically circular section. On the front of each was a Tumanskii (Mikulin KB) M-87B 14-cylinder radial engine (Gnome-Rhone ancestry) rated at 950hp, driving a VISH-23D three-blade variable-pitch propeller of 3.3m (10ft 10in) diameter weighing 152kg (335 lb). The engines were housed in modern long-chord cowlings, with pilot-operated cooling gills. Tanks in the wings and fuselages housed 3,444 litres (757.6 Imperial gallons, 910 US gallons) of fuel, with all tanks protected by nitrogen inerting.

On the centreline at the rear was a large (7.0m², 75.3ft²) single fin and a 1.94m² (20.9ft²) rudder with a large trim tab. High on the fin,



above the rudder, was fixed a small (0.85m^2 , 9.15ft^2) tailplane to which were pivoted the enormous elevators of 4.8m^2 (51.7ft^2) total area, each with a large tab.

Each fuselage was provided with a main landing gear, with a single oleo strut on the outer side of the axle for a single wheel with a $900 \times 300\text{mm}$ tyre, with a hydraulic brake. Each unit retracted rearwards hydraulically. On the centreline at the rear was the fixed castoring tailwheel, with a 450×150 tyre.

The intention was that the series (production) DB-LK should have a pilot in the front of the left fuselage, a navigator in front on the right, and gunners in each tailcone. The gunners, entering like the others via roof hatches, should manage the radio as well as pairs of ShKAS 7.62mm machine guns, with a $\pm 10^\circ$ field of fire in all directions. Two more ShKAS fired ahead on the centreline, aimed by the pilot, and for the six guns a total of 4,500 rounds were provided. Behind each main-gear bay was a bomb bay, with powered doors (see underside view). Each could carry an FAB-1000 (2,205 lb) bomb, or four FAB-250 (551 lb) bombs, or many other smaller stores. Predictably, the full military equipment was never fitted, though radio was installed throughout the flight trials.

Despite its strikingly unconventional appearance, the DB-LK appeared to be a practical bomber with outstanding flight performance. Compared with the established WS bomber it had the same number of similar engines, and even half the number of landing-gear oleos, despite having twice the number of fuselages and weapon bays. From today's distance, it might have been worth pursuing this formula a little further.

Dimensions

| | | |
|-----------|-------------------|------------------|
| Span | 21.6m | 70 ft 10 1/4 in |
| Length | 9.78 m | 32 ft 1 in |
| Wing area | 56.87m^2 | 612ft^2 |

Note: various other figures for span (21.4 m) and wing area (59m^2) have appeared.

Weights

| | | |
|--------------------------------|-----------|-----------|
| Empty (also given as 5,655 kg) | 6,004 kg | 13,236 lb |
| Normal loaded weight | 9,061 kg | 19,976 lb |
| Max loaded weight | 10,672 kg | 23,528 lb |

(also given as 9,285 kg)

Performance

| | | |
|--------------------------------|----------|-------------|
| Max speed at sea level, | 395 km/h | 245 mph |
| at 5,100m (16,730 ft) | 488 km/h | 303 mph |
| Take-off speed | 145 km/h | 90 mph |
| Max rate of climb | 6.15m/s | 1,210ft/min |
| Time to climb to 3,000 m | 8.2 min | (9,843ft) |
| Time to climb to 5,000 m | 13.6 min | (16,404ft) |
| Service ceiling | 8,500 m | 27,890ft |
| Range (with 1,000 kg bombload) | | |
| at normal gross weight | 1,270 km | 789 miles |
| maximum | 2,900 km | 1,800 miles |
| Landing speed | 150 km/h | 93 mph |

Four views of DB-LK, one showing landing-gear failure.

Belyayev FBI

Purpose: Experimental dive-bomber fighter.
Design Bureau: V N Belyayev.

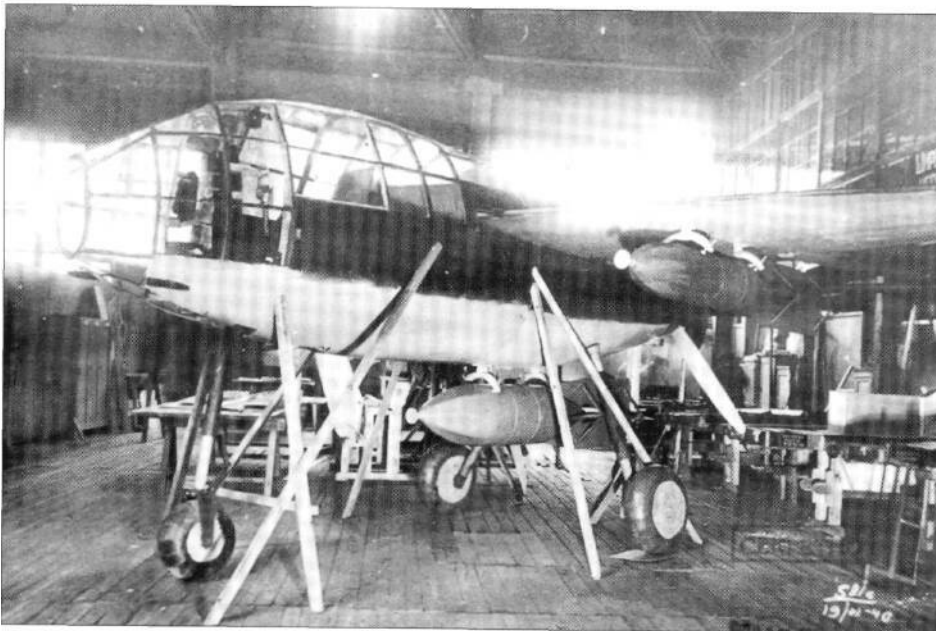
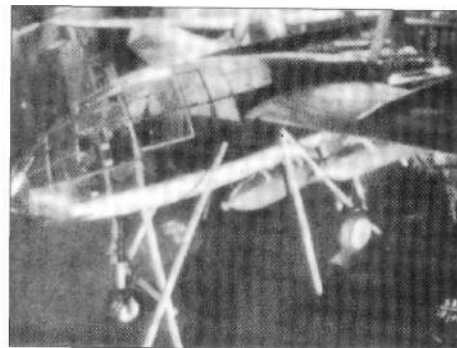
No descriptive material has come to light regarding the proposed FBI (Russian for dive-bomber fighter). Only recently have photographs of the mock-up been discovered, marked SEKRETN and dated 19/11-40. When these photographs were unearthed and identified nothing was known of such an aircraft, and it was concluded that this was the mock-up of the EOI fighter, especially as Shavrov said this was a twin-boom aircraft. Studying the photographs makes it obvious that the FBI was what its designation states, and not primarily a fighter. Almost the only fact deducible under the heading 'History' is that the date is one month after the evacuation of the factories in the Moscow area.

In some respects the FBI design is similar to the EOI fighter. The forward fuselage has two cannon in the same undernose position, the single-seat cockpit has similar features, the wing is in the same mid-position, immediately behind it is the engine driving a three-blade pusher propeller and the twin booms and tail are similar. The differences are that the cockpit area is almost completely glazed, and the landing gears are taller to facilitate loading bombs on five racks (apparently an FAB-500 on the centreline and for an FAB-100 and FAB-50 under each wing).

It is unlikely that Belyayev - even assisted by his team of P N Obrubov, L L Selyakov, E I Korzhenevskii, D A Zatvan, B S Beki and

N Ye Leont'yev - could simultaneously have worked on the DB-LK, Babochka and two advanced pusher fighters and bombers. The inference has to be that the FBI did not progress far beyond the mock-up. This may have been photographed after the workers had left, immediately before it was destroyed, or alternatively it may have been safely located (but abandoned) somewhere East of Moscow.

Specification. No figures known.



Two views of the FBI mock-up.

Belyayev 370, EOI

Purpose: Experimental fighter.
Design Bureau: V N Belyayev, working at GAZ (factory) No 156, Moscow.

This EOI (Eksperimental'nyi Odnomestnyi Istrebitel', experimental single-seat fighter) was proposed in early 1939, and personally approved by Stalin in August of that year. Design and manufacture proceeded through 1940, and at the German invasion of 22nd June 1941 the first flight was only a few months away.

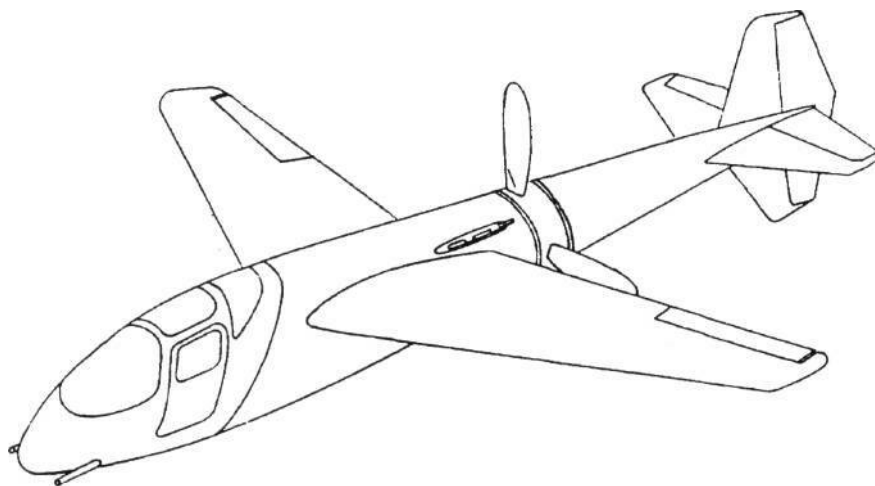
In October the Moscow factories were evacuated. It was decided to abandon the project, and the part-complete EOI, drawings and calculations were destroyed. When photographs of the FBI (see above) were discovered it was at first thought that this must be the same aircraft. In fact, there was little similarity between the two designs apart from the basic configuration.

The EOI had the cockpit in the nose, almost perfectly streamlined, with armament in the same location. Possibly for the first time in history, Belyayev designed the entire front section of the aircraft to be separated in emergency, so that the pilot would not have to bail out ahead of the propeller. The latter was to be driven by a Klimov M-105 engine, rated at 1,100hp and fitted with a TK-2 turbocharger. In the original scheme, like fighters of 1917 by Gallaudet in the USA and Dufaux in France, the propeller was to have a large-diameter hub through which passed a tube carrying the rear fuselage. Some of the '370' drawings are reproduced overleaf. One shows the proposed cockpit, armament of two underfloor VYa-23 cannon and location of the cartridge-severed attachments. Another drawing shows the unique arrangement in which the wing was to be provided with a slat. This auxiliary surface was normally

housed in a recess immediately ahead of the flap or aileron. For take-off and landing it was to be swung down and forward to adopt a leading-edge-down attitude ahead of the leading edge of the wing. Thus, it was a bolder precursor of today's Krueger flap. Whether or not this aerodynamically powerful idea was abandoned is unknown, but Belyayev certainly abandoned the original rear fuselage. By late 1939 he had decided to use conventional twin tail booms. The specification overleaf applies to this revised scheme.

According to one document it was intended that a production version should have had the M-106 engine. This would have been rated at 1,350hp, instead of 1,100hp. Whether the unconventional configuration, and especially the potentially dangerous slat system, would have shown to advantage will never be known.

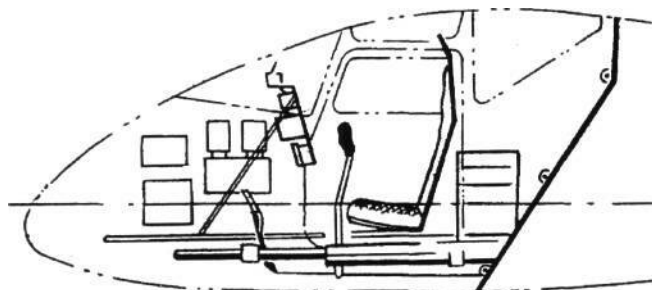
Sketch drawings of 370



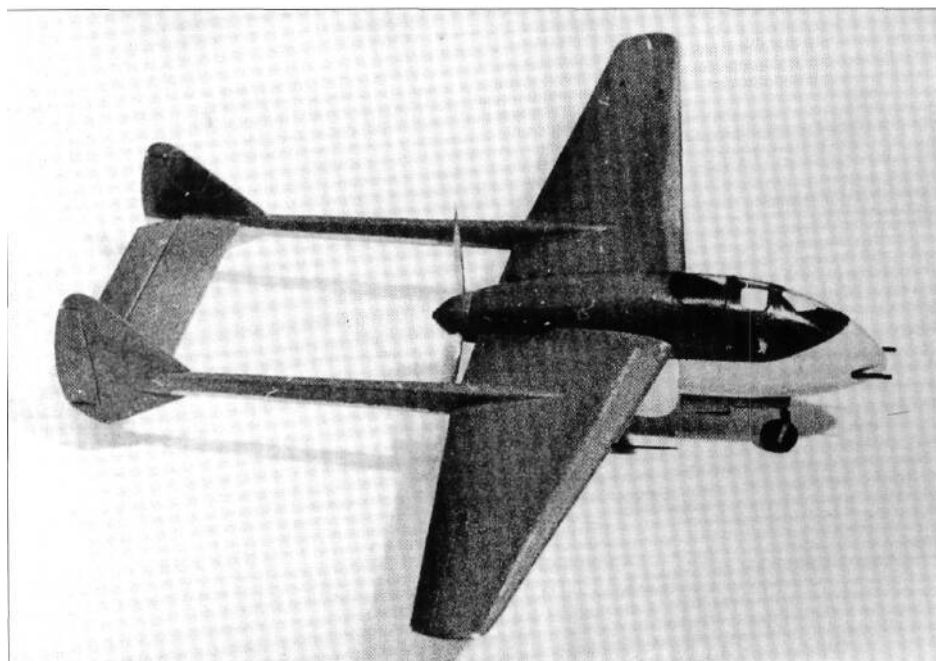
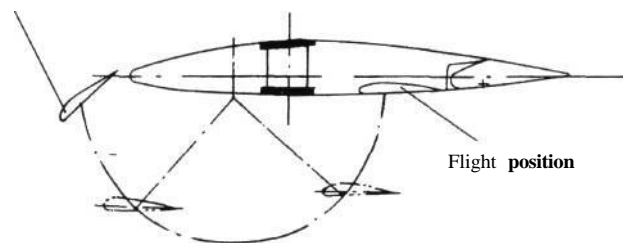
Dimensions

| | | |
|--------------|-------------------|---------------------|
| Span | 11.4m | 37 ft 5 in |
| Wing area | 19 m ² | 205 ft ² |
| Design speed | 700 km/h | 435 mph |

No other data.



On take-off and landing



Model of the final EOI configuration.

Bereznyak-Isayev BI

Purpose: Experimental rocket-engined interceptor-fighter.

Design Bureau: Designers Aleksandr Yakovlevich Bereznyak and Aleksei Mikhailovich Isayev, working at OKB of Bolkhovitinov, later managed by CAHI (TsAGI).

In 1939 Bereznyak was an observer at the static tests of the first reliable rocket engine developed by Leonid Stepanovich Dushkin. In early 1940 he watched flight tests of the primitive RP-318 (see later under Korolyev). He discussed rocket aircraft with Isayev, who had been a Dushkin engineer involved with the RP-318. In late May 1941 they decided to propose a high-speed rocket-engined fighter. They put the suggestion to Prof Bolkhovitinov (see later entry). After discussion with all interested parties Bolkhovitinov sent a letter to GUAP (chief administration of aviation industry) on 9th July 1941 putting forward a detailed proposal. Soon a reply came from the Kremlin. The principals were called to GUAP before Shakhurin and A S Yakovlev, and within a week there was a full go-ahead. The order was for five prototypes, with the time to first flight cut from the suggested three months to a mere 35 days.

A complete Bolkhovitinov team were confined to the OKB for 40 days, working three shifts round the clock. Tunnel testing was

done at CAHI, supervised by G S Byushgens. The first (unpowered) flight article was built without many drawings, dimensions being drawn directly on the materials and on templates. B M Kudrin made the first flight on 10th September 1941, the tug being a Pe-2. All necessary data were obtained in 15 flights. On 16th October the OKB and factory was evacuated to a half-built shed outside Sverdlovsk. The first (experimental) D-1A engine was installed in late January 1942, but exploded during testing on 20th February, injuring Kudrin (sent to hospital in Moscow) and a technician. The replacement pilot was Capt G Ya Bakhshivandzhi. He was in the cockpit on the first tied-down firing on 27th April 1942. On 15th May 1942 he made the world's first flight of a fully engineered rocket interceptor, still fitted with skis.

By March 1943 seven BI prototypes had been constructed, but the flying was entirely in towed or gliding flight because of serious problems caused by explosions and acid spillages. Powered flying did not resume until February 1943. By this time Kudrin had returned to flight status, and was assigned one of the Bis. On powered flight No 6 on 21st March 1943 a height of 3km (9,843ft) was reached in 30 seconds. On powered flight No 7, with aircraft No 3, on 27th March, Bakhshivandzhi made a run at sustained full power; the aircraft suddenly pitched over and

dived into the ground. Tunnel testing later showed that at about 900km/h the BI would develop a nose-down pitching moment which could not be held by the pilot.

Dimensions

| | | |
|-----------------|-------------------|---------------------|
| Span | | |
| Nos 1 and 2 | 6.48m | 21 ft 3 in |
| Nos 3 and later | 6.6 m | 21 ft 8 in |
| Length | | |
| Nos 1 and 2 | 6.4 m | 21ft |
| Nos 3 and later | 6.935 m | 22 ft 9 in |
| Wing area | | |
| Nos 1 and 2 | 7.0m ² | 75.3ft ² |
| No 3 | 7.2m ² | 77.5ft ² |

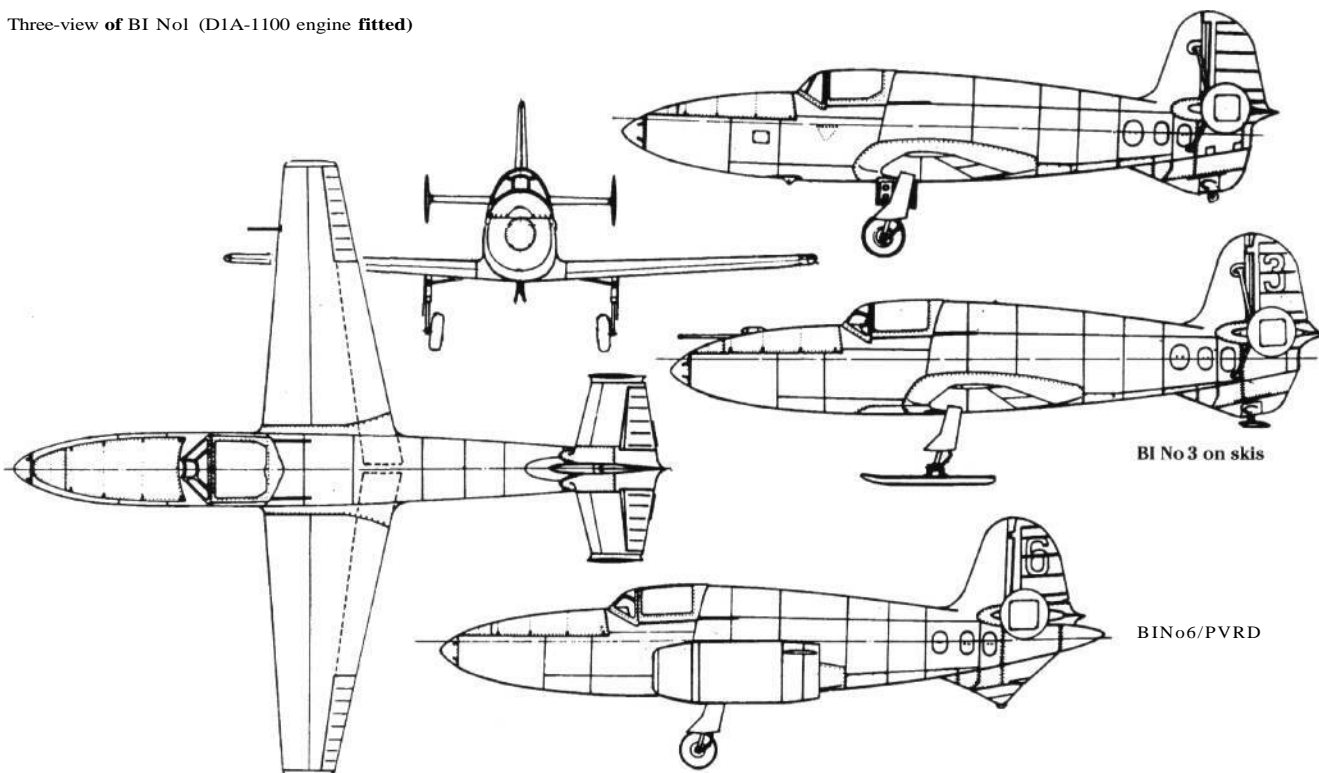
Weights

| | | |
|--------|---------|----------|
| Empty | | |
| No 1 | 462 kg | 1,019 lb |
| No 3 | 790kg | 1,742lb |
| No 7 | 805kg | 1,775lb |
| Loaded | | |
| No 3 | 1,650kg | 3,638lb |
| No 7 | 1,683kg | 3,710 lb |

Performance

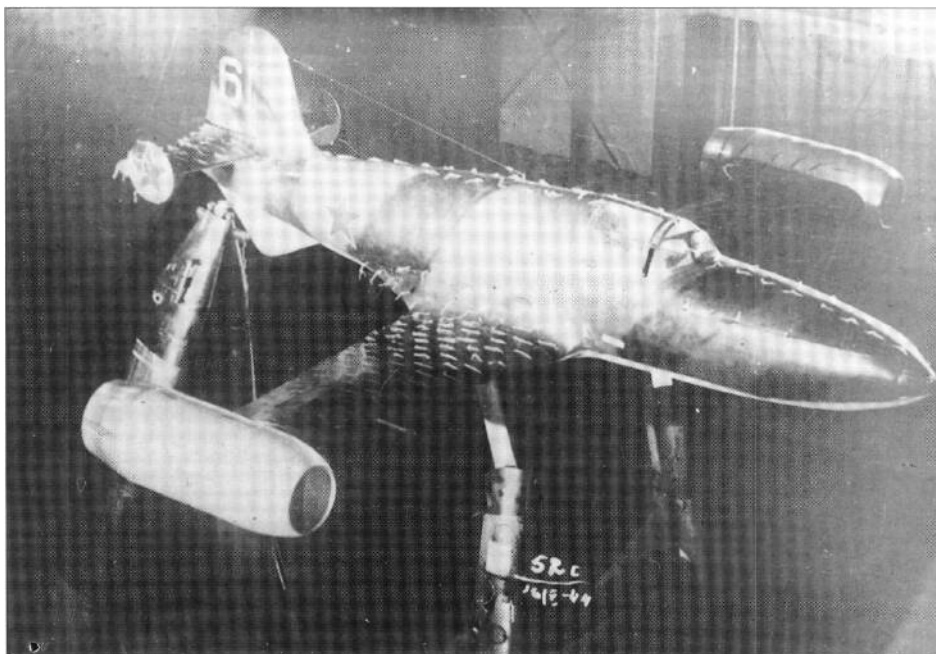
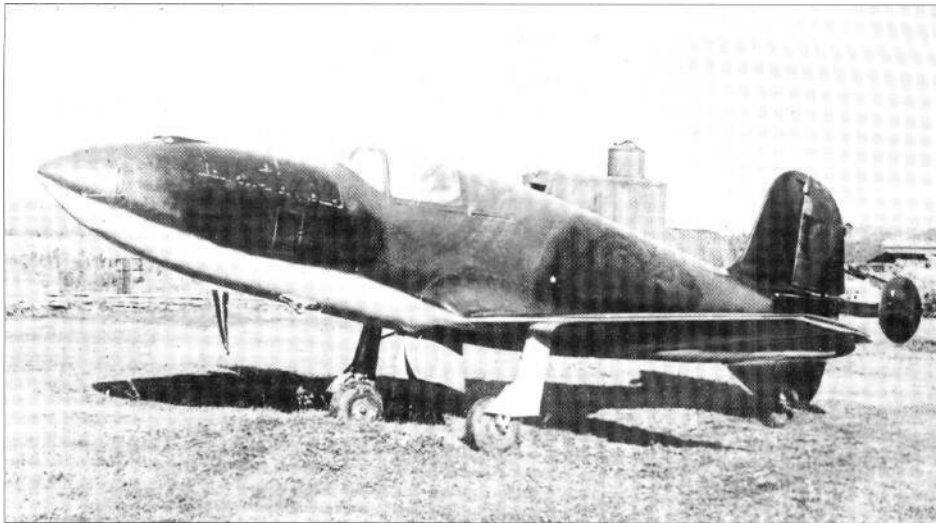
| | | |
|--|------------|---------------|
| Maximum speed | | |
| original estimate | 800 km/h | 497 mph |
| achieved | 900 km/h | 559 mph |
| 1943 high-altitude estimate, not attempted | 1,020 km/h | 634 mph |
| Time to accelerate from 800 to 900 km/h | | 20 seconds |
| Take-off run | 400m | 1,310ft |
| Initial climb | 120m/s | 23,622 ft/min |
| Time to 5,000 m | 50 seconds | 16,404ft |
| Endurance under full power | 2 min | |
| Landing speed | 143 km/h | 89 mph |

Three-view of BI No 1 (D1A-1100 engine fitted)



BI No 3 on skis

BI No 6/PVRD



Top: BI No 1. Centre: Bakhchivandzhi with BI No 2. Bottom: BI No 6/PVRD in tunnel.

This terminated the delayed plan to build a production series of 50 slightly improved aircraft, but testing of the prototypes continued. Until the end of the War these tested various later Dushkin engines, some with large thrust chambers for take-off and combat and small chambers to prolong the very short cruise endurance (which was the factor resulting in progressive waning of interest). Other testing attempted to perfect a sealed pressurized cockpit. To extend duration significantly BI No 6 was fitted with a Merkulov DM-4 ramjet on each wingtip. These were fired during test in the CAHI T-101 wind tunnel, but not in flight.

By 1944 the urgency had departed from the programme, and the remaining BI No 1 (some were scrapped following acid corrosion) were used as basic research aircraft. BI No 7 was modified with revised wing-root fairings and stronger engine cowl panels, but at high speed tailplane flutter was experienced. BI No 5s (on skis) and BI No 6 (on wheels) were modified and subjected to investigative gliding tests, initially towed by a B-25J.

In 1948 Bereznyak proposed a mixed-power interceptor with a three-chamber rocket engine of 10,000kg (22,046 lb) sea-level thrust, for 'dash' performance, and a Mikulin AM-5 turbojet of 1,900kg (4,189 lb) sea-level thrust. Estimated maximum speed was Mach 1.8, and range 750km (466 miles). This was not proceeded with.

The BI No 1 had a small and outstandingly simple all-wood airframe. The straight-tapered wing, 6 per cent thick, had two box spars and multiple stringers supporting skin mainly of 2mm ply. Outboard were fabric-covered ailerons. Inboard were split flaps with light-alloy structure (the only major metal parts), with a landing angle of 50°. The fuselage was a plywood monocoque with fabric bonded over the outer surface. It was constructed integral with the upper and lower fins. The rudder and elevators were fabric-covered. On the tailplane were added small circular endplate fins, and the powered aircraft had the tailplane braced to both the upper and lower fins.

The engine bay was lined with refractory materials and stainless steel. The standard engine was the Dushkin D-1A-1100, the designation reflecting the sea-level thrust (2,425 lb), rising to about 1,300kg (2,866 lb) at high altitude. The propellants, fed by compressed air, were RFNA (red fuming nitric acid) and kerosene. These were contained in cylindrical stainless-steel tanks in the centre fuselage. The pneumatic system not only fed the propellants but also charged the guns and operated the flaps and main landing gears. The latter retracted inwards into the wings and normally had wheels with 500 x 150 tyres. Under the ventral fin was a retracting tail-

wheel. In winter these units were replaced by skis, the main skis retracting to lie snugly under the wings.

The cockpit had a simple aft-sliding canopy, and a bulletproof windscreen. Certain of the prototypes had armament, comprising two ShVAK 20mm cannon, each with 45 rounds, fired electrically and installed in

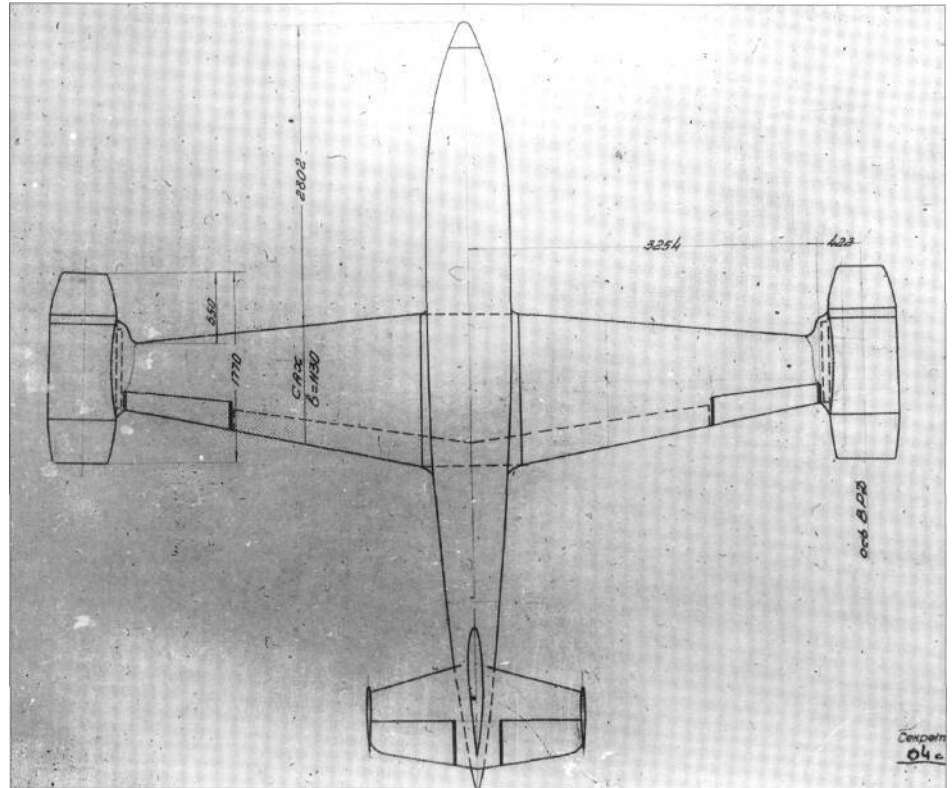
the upper half of the nose under a cover secured by three latches on each side. Between the spars under the propellant cylinders was a bay which in some aircraft could house a small bomb load (see below). Structural factor of safety was 9, rising to no less than 13.5 after using most of the propellants.

By any yardstick the BI No 1 was a remark-

able achievement, and all pilots who flew it thought it handled beautifully. It was killed by the time it took to overcome the problems, and - crucially - by the impracticably short flight endurance.

The nominal weight breakdown for a fully equipped powered aircraft was:

| | | |
|--------------------------|---------|-----------|
| Airframe | 462kg | 1,018.5lb |
| Comprising fuselage | 182kg | 401 lb |
| Wing | 174kg | 383.6 lb |
| Tail group | 30kg | 66 lb |
| Landing gear, wheeled | 60kg | 132lb |
| Engine | 48kg | 106 lb |
| Controls | 16kg | 35 lb |
| RFNA tanks | 80kg | 176.4lb |
| Kerosene tanks | 31.2kg | 68.8 lb |
| Airbottles | 22.4kg | 49.4 lb |
| Guns | 84kg | 185 lb |
| Armour | 76 kg | 167.5lb |
| Armour glass, windscreen | 6kg | 13 lb |
| Other equipment about | 20kg | 44 lb |
| Useful load comprised | | |
| Pilot | 90kg | 198 lb |
| Nitric acid | 570kg | 1,256.6lb |
| Kerosene | 135kg | 297.6 lb |
| 20mm ammunition | 19.6kg | 43.2 lb |
| Bombs | 38.4 kg | 84.6 lb |



OKB drawing of BI No 6/PVRD.

BerievS-13

Purpose: To copy the Lockheed U-2B.

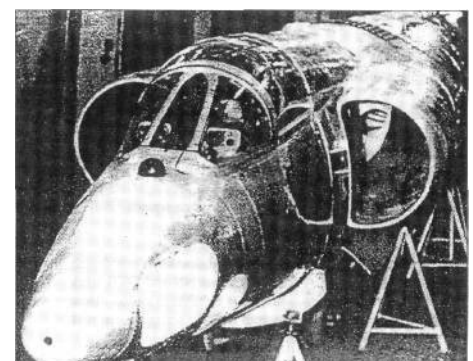
Design Bureau: OKB No 49, Taganrog, General Constructor G M Beriev.

On 1st May 1960 the world was astonished to learn that the missile defences of Sverdlovsk had shot down a Lockheed U-2 of the US Central Intelligence Agency. Parts of the aircraft were put on display in Moscow's Gorkiy Park. What the world was not told was that for months afterwards a vast area was combed by large squads looking for every fragment of the downed aircraft (which had broken up at high altitude). All the pieces were brought to GK Nil WS, where they were carefully studied. On 28th June 1960 SovMin Directive 702-288 instructed OKB No 16 in Kazan, led by P F Zubets, to copy the J57-P-13 engine. This was a blow to Zubets, whose RD-500 was in the same thrust class, and even more to the several engine designers (Dobrynin, Lyul'ka, Kuznetsov and Tumanskii) who had engines on test which were more

powerful and of much later design than the massive Pratt & Whitney. On 23rd August 1960 Directive 918-383 ordered OKB No 49, assisted by neighbouring No 86, to study the U-2 and produce five copies, designated S-13. These were primarily to support 'a multi-discipline study of the structural, technical and maintenance aspects of the U-2, and master its technology for use in indigenous aircraft'. It was also expected that the S-13 would be used to collect upper-atmosphere samples, destroy hostile balloons and (using the 73-13, or AFA-60, camera) undertake reconnaissance missions. Despite inexorable increases in weight over the US original, work attempted to meet the first-flight date of first quarter 1962. Much of the supporting equipment had already been developed for the Yak-25RV and TsybinRSR (which see). On 1st April 1961 a detailed metal fuselage mock-up was completed, with 'models of its systems'. A Tu-16 was readied for testing the engine (now designated RD-16-75), landing gears

and other items, while CAHI tunnels confirmed that the U-2 had the exceptional L/D ratio of 25. Out of the blue, on 12th May 1962 Directive 440-191 ordered the whole S-13 project to be terminated.

S-13 metal mock-up fuselage.



BICH-3

Purpose: To test previously invented 'parabola wing' in a powered aircraft
Design Bureau: Not an OKB but a private individual, Boris Ivanovich Cheranovskii (1896-1960). Throughout his life he scratched around for funds to build and test his succession of **30** types of gliders and powered aircraft, all of 'tailless' configuration.

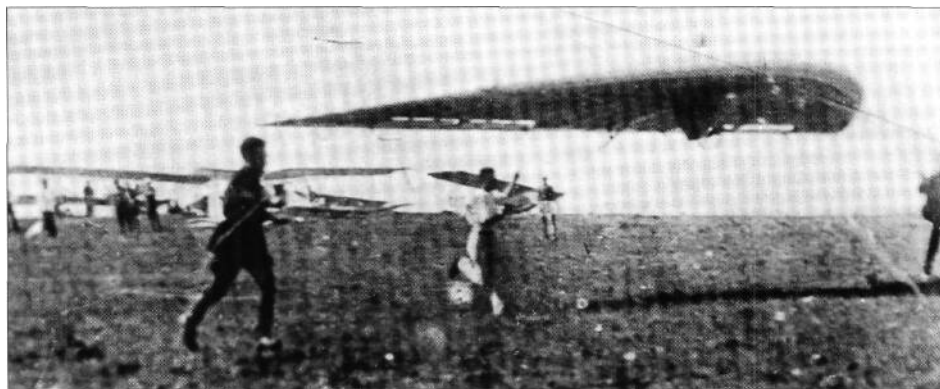
In 1924 Cheranovskii tested his BICH-1 'Parabola' glider and the refined BICH-2, which demonstrated 'normal longitudinal stability and controllability and is considered to have

been the world's first successful flying wing'. In 1926 he followed with the BICH-3, which was almost the BICH-2 fitted with an engine. Cheranovskii's gliders had been flown at the All-Union meetings at Koktebel, Crimea, but most of the flying of his first aeroplane was done by B N Kudrin (later famous) in Moscow.

The BICH-3 was a basically simple aircraft, constructed of wood with thin ply skin over the leading edge, inboard upper surface and landing-gear trousers, and fabric elsewhere. The BICH-2 had flown without a rudder (it was better with one) since turning was

achieved by the ailerons. With the BICH-3 the addition of an engine required a vestigial fuselage with a fin and rudder. The main controls remained the trailing-edge elevators and ailerons, operated by rods and bellcranks and hung on inset balanced hinges. The engine was a Blackburne Tomtit, an inverted V-twin of 698 cc rated at 18hp. Skids were provided under the tail and outer wings.

Kudrin described the BICH-3 as 'not very stable, but controllable'. It was sufficiently successful to lead to the many successors.

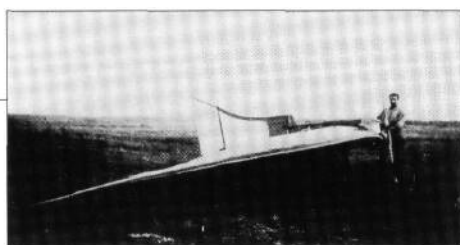


| Dimensions | | |
|------------|--------------------|--------------------|
| Span | 9.5m | 31 ft 2 in |
| Length | 3.5m | 11 ft 6 in |
| Wing area | 20.0m ² | 215ft ² |

| Weights | | |
|----------|-------|--------|
| Empty | 140kg | 309 lb |
| Fuel/oil | 10kg | 22 lb |
| Loaded | 230kg | 507 lb |

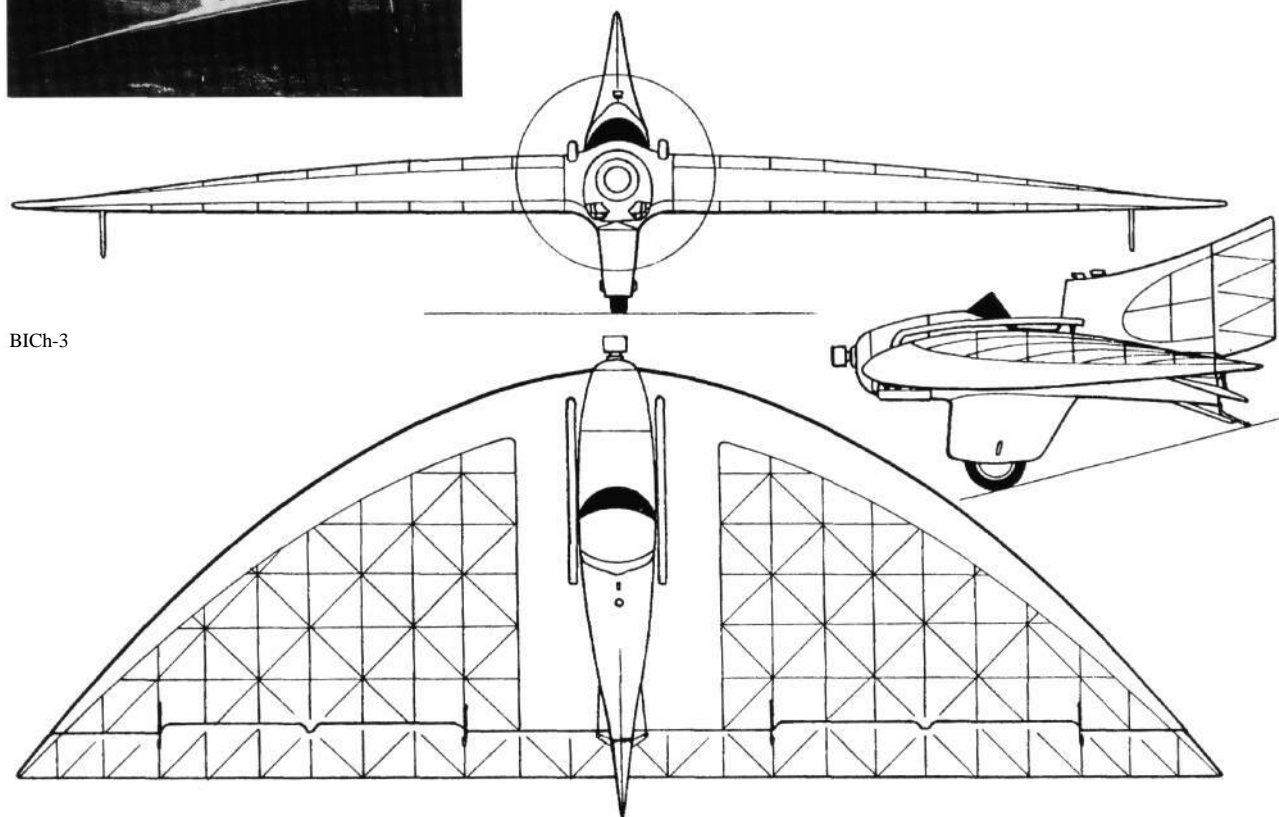
| Performance | | |
|-------------------------|--------|--------|
| Max speed, not recorded | | |
| Landing speed | 40km/h | 25 mph |

No other data.

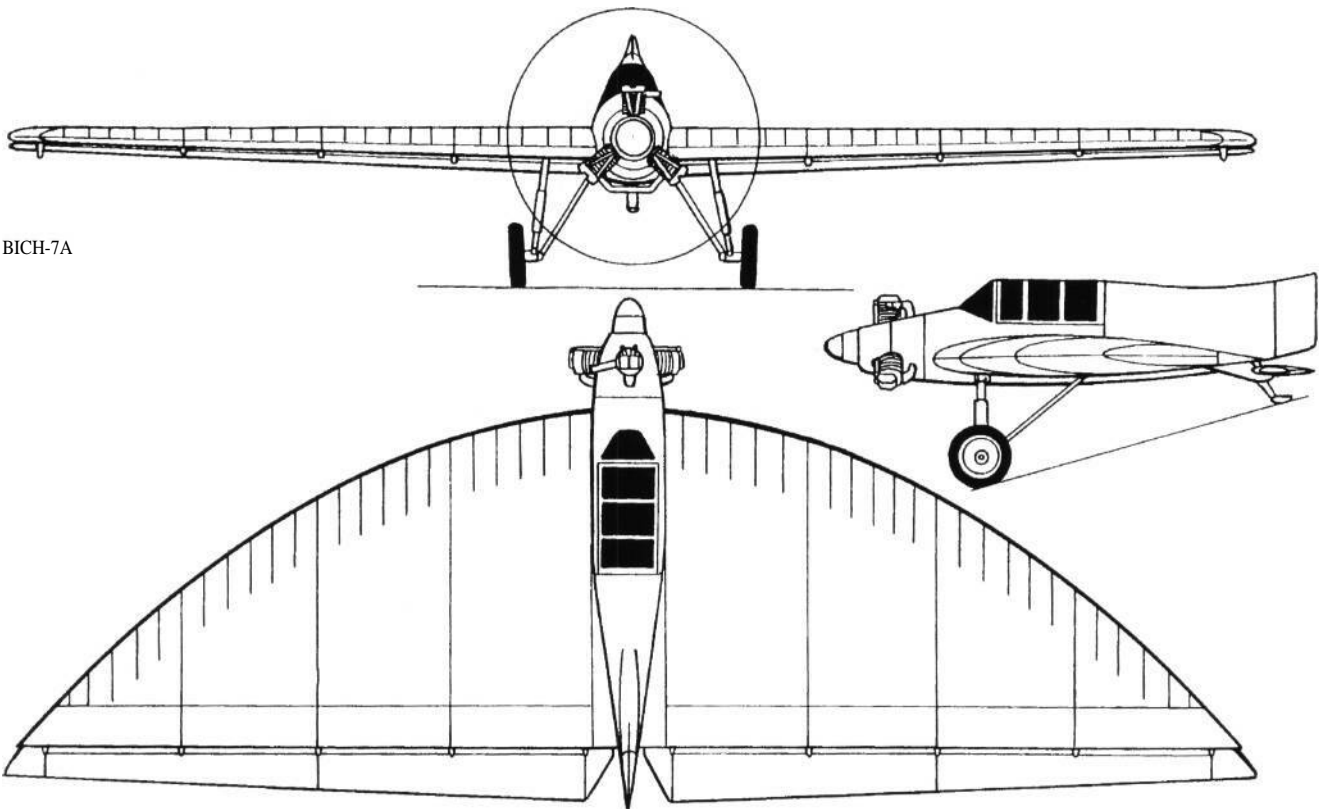


Above: BICH-1.

Left: Cheranovskii with BICH-3.



BICH-7A



BICH-7A

Purpose: To improve BICH-7, the next stage beyond BICH-3.
Design Bureau: B I Cheranovskii.

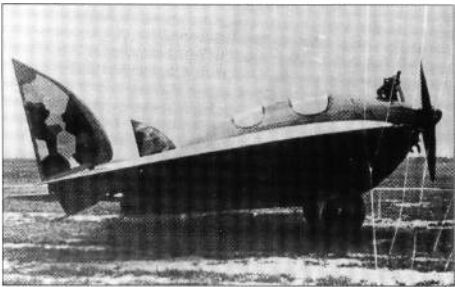
BICH followed his Type 3 with the impressive BICH-5 bomber, powered by two BMW VI engines, but never obtained funds to build it. In 1929 he flew the BICH-7, almost a 1.5-scale repeat of BICH-3 with two seats in tandem. The problem was that he replaced the central tail by rudders (without fixed fins) on the wingtips, and the result was almost uncontrollable. He modified the aircraft into the BICH-7A, but was so busy with the BICH-11 and other projects that the improved aircraft did not fly until 1932. Apart from returning to a central fin and rudder he replaced the centreline wheel and wingtip skids by a conventional landing gear. The BICH-7A gradually became an outstanding aircraft. Testing was done mainly by N P Blagin (later infamous for colliding with the monster Maksim Gorkii), and he kept modifying the elevators and ailerons until the aircraft was to his satisfaction.

This larger 'parabola-wing' aircraft was again made of wood, veneer and fabric, with various metal parts including the conventional divided rubber-sprung main landing gears and tailskid. The tandem cockpits were en-

closed, which in 1932 was unusual. The engine was a 100hp Bristol Lucifer, and one of the unsolvable problems was that the Lucifer was notorious for the violence of the firing strokes from its three cylinders, which in some aircraft (so far as we know, not including the BICH-7A) caused structural failure of its mountings.

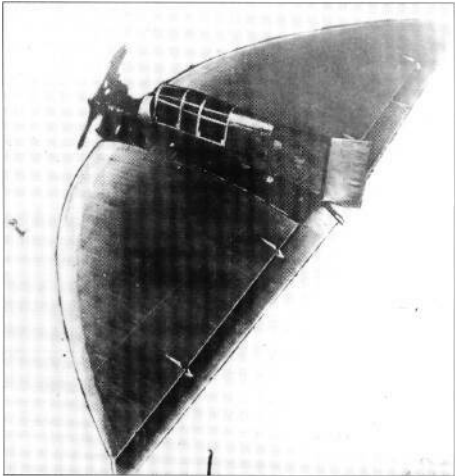
This aircraft appears to have become an unqualified success, appearing at many airshows over several years.

| | | |
|------------------|---------|---------------------|
| Dimensions | | |
| Span | 12.5m | 41ft |
| Length | 4.95m | 16 ft 3 in |
| Wing area | 34.6 nf | 372 ft ² |
| Weights (BICH-7) | | |
| Empty | 612kg | 1,349lb |
| Fuel/oil | 93kg | 205 lb |
| Loaded | 865kg | 1,907lb |
| (BICH-7A) | | |
| Empty | 627kg | 1,382lb |
| Fuel/oil | 93kg | 205 lb |
| Loaded | 880kg | 1,940lb |
| Performance | | |
| Maximum speed | 165km/h | 102.5 mph |
| Range | 350km | 217miles |
| Landing speed | 70km/h | 43.5 mph |



BICH-7

BICH-7A



BICH-8

Purpose: To test the use of wingtip rudders.

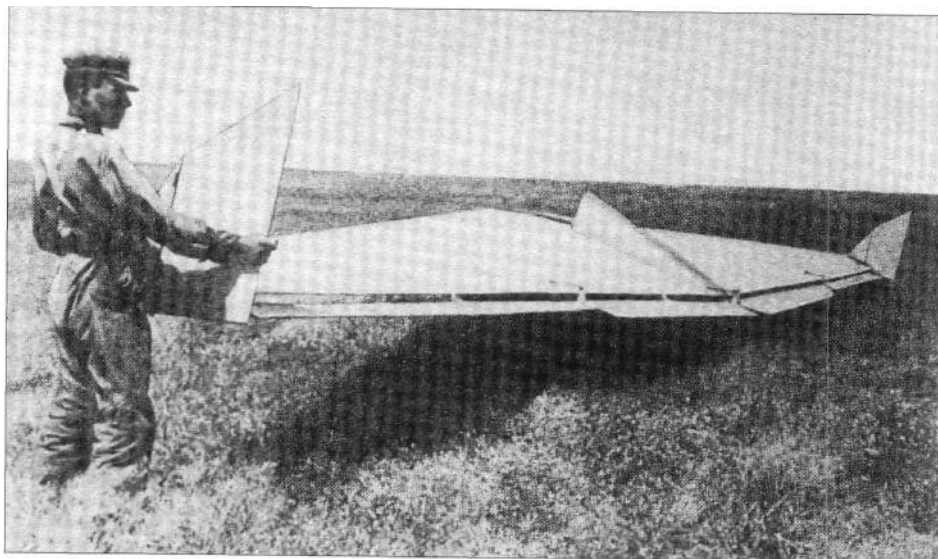
Design Bureau: B I Cheranovskii.

Few details of this machine have survived. It was built and tested in 1929. Cheranovskii was so distressed by the failure of the BICH-7 that he built this simple glider to see if wingtip rudders could be made to work.

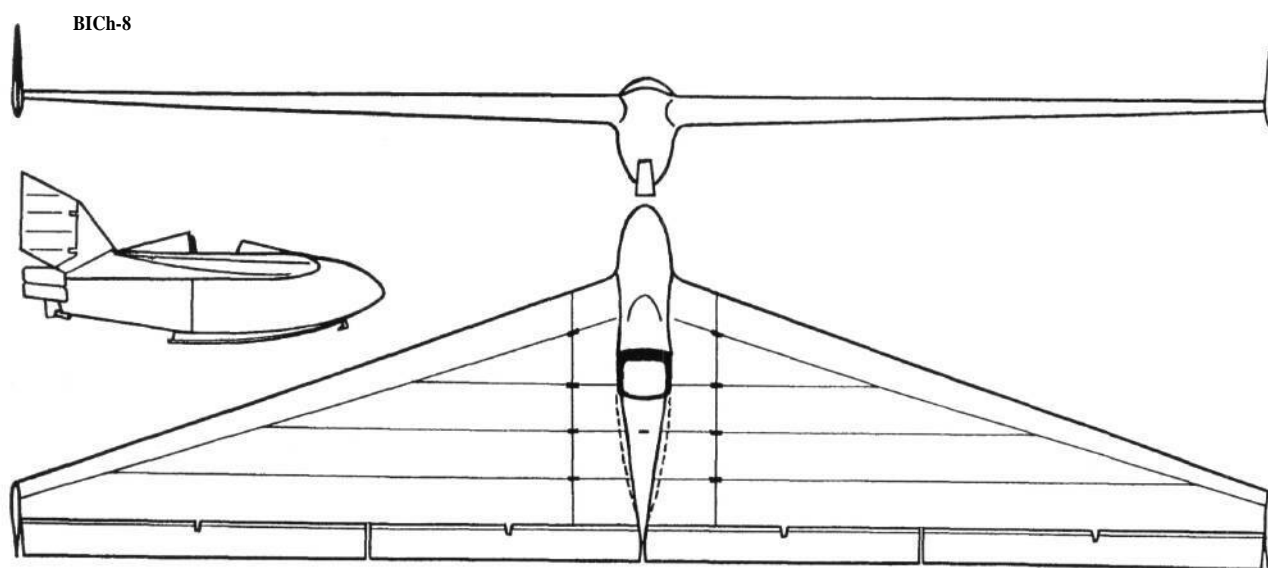
The BICH-8 was dubbed Treoogol'nik (little triangle). It had an open cockpit and centre-line skid. The wing was built as a centre section, integral with the nacelle, and outer panels fitted with inboard elevators, outboard ailerons and wingtip rudders with inset hinges mounted on small fins.

This machine may have flown satisfactorily, because Cheranovskii repeated tip rudders in the BICH-11.

No data.



Cheranovskii with BICH-8.



BICH-11, RP-1

Purpose: To test rocket engine in flight.

Design Bureau: B I Cheranovskii.

The BICH-11 was designed in 1931 as a bungee-launched glider to see if the concept of using wingtip rudders could be made to work. The glides may have been too brief to be useful, because in 1932 Cheranovskii added a small British engine more powerful than the Tomtit used for BICH-3. In 1933 this aircraft was selected by MosGIRD, the Moscow-based experimental rocket-engine

group, as a suitable test-bed with which to fly a small liquid-propellant rocket engine, which began bench-testing on 18th March 1933. The aircraft was again modified, with the rocket engine(s) and their supply and control system and a new wing of increased span. It was then judged that the propulsion system was too dangerous to fly. Note: some accounts say the piston engine was installed after the removal of the rocket engine(s), but drawings show the piston-engined aircraft to have had the original wing.

The BICH-11 was another wooden aircraft with fabric covering, with a single seat, hinged canopy and trailing-edge elevators and ailerons. It appears to have had no landing gear other than a centreline skid. On the wingtips were rudders, under which were skids. In its powered form the engine was an ABC Scorpion with two air-cooled cylinders, rated at 27/35hp. The rocket engine was the GIRD OR-2, designed by a team led by FATSander, with a single thrust chamber burning petrol (gasoline) and liquid oxygen.

Sea-level thrust was 50kg (110 lb). The BICH-11 was given a wing of greater span, and fitted with sprung landing gears and a tailskid. There is confusion over whether one or two OR-2 engines were installed (drawings suggest one), fed by a lagged spherical tank of liquid oxygen and a smaller bottle of fuel, all fed by gas pressure. In this form the aircraft was painted red overall, with 'GIRD RP-1' painted on each side of the vestigial fuselage. RP stood for Raketnyi Planer, rocket glider.

It is not recorded whether this aircraft flew satisfactorily with wingtip rudders, which with BICH-7 had proved unsatisfactory.

Dimensions (as RP-1)

| | | |
|-----------|--------------------|--|
| Span | 12.1m | 39 ft 8 ¹ / ₂ in |
| Length | 3.09m | 10 ft 1 ¹ / ₂ in |
| Wing area | 20.0m ² | 215 ft ² |

Weights

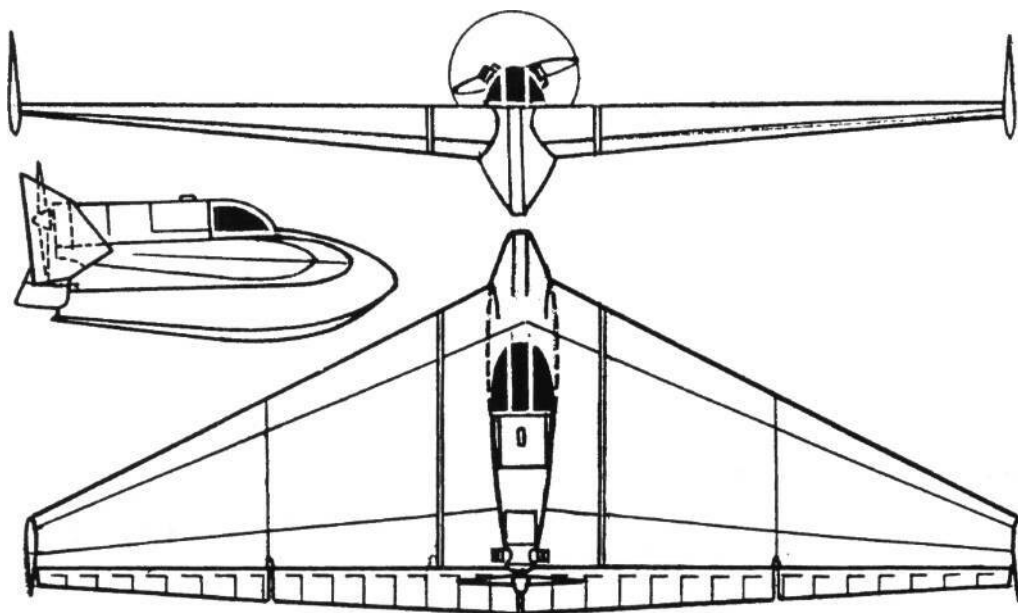
| | | |
|-------|-------|--------|
| Empty | 200kg | 441 lb |
|-------|-------|--------|

No other reliable data.

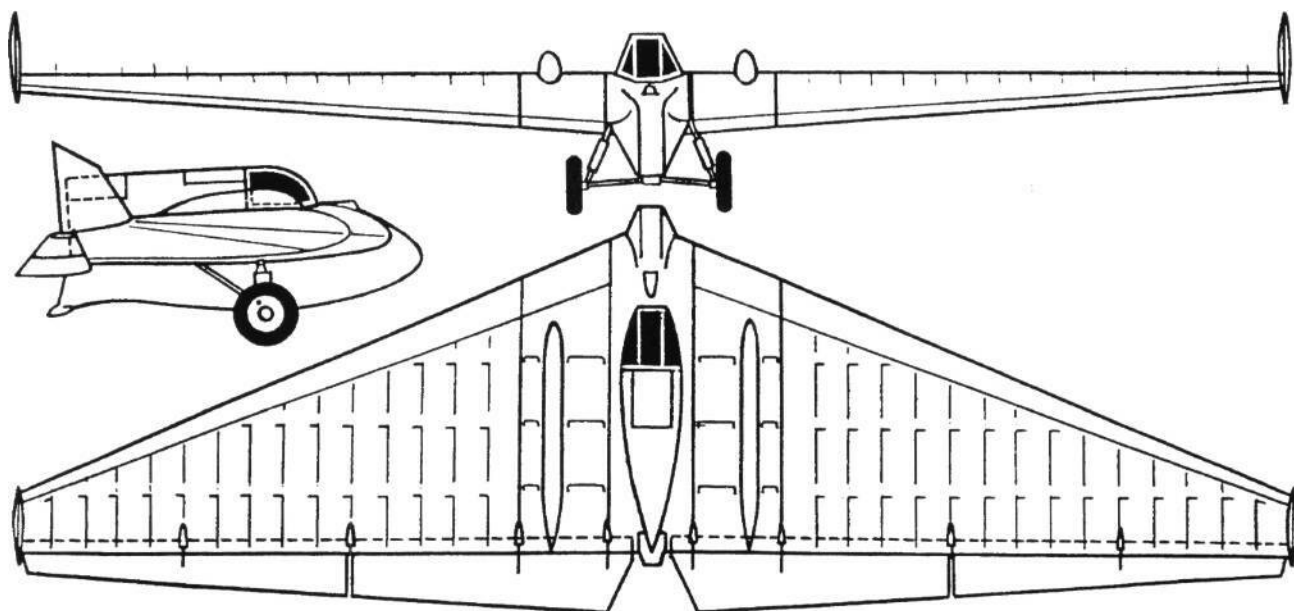


Cheranovskii with RP-1.

BICH-11



RP-1



BICH-14

Purpose: To test an improved twin-engined 'Parabola'.

Design Bureau: B I Cheranovskii.

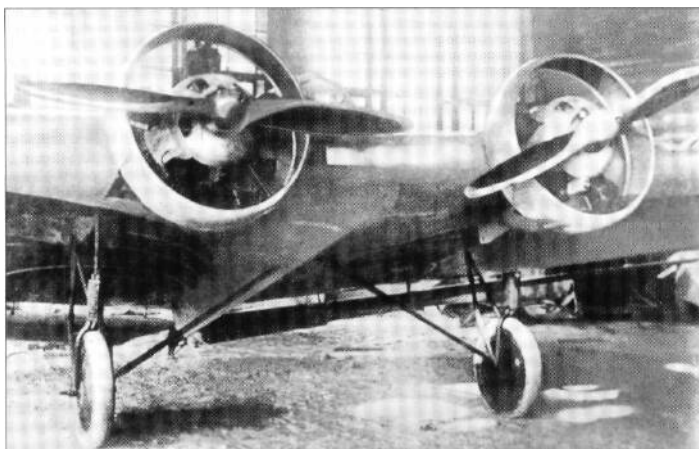
In 1933 Cheranovskii schemed his first design with twin engines, the BICH-10. Later in that year he tested a tunnel model, and by 1934 he had made so many (mostly minor) changes that he redesignated it as the BICH-14. It interested the Central Construction Bureau, and thus received their designation CCB-10 (TsKB-10). With their assistance the aircraft was built, and the flight-test programme was opened at the end of 1934 by Yuri I Piontkovskii. Having no slipstream, the rudder was ineffective, and it was difficult to equalise pro-

peller thrusts. On landing, with engines idling, a heavy stick force was needed to get the tail down. Though it was not one of the better BICH designs, having almost no directional stability and being extremely reluctant to respond to pilot inputs, it was submitted for NII-WS testing. Here such famous pilots as Stefanovskii, Petrov and Nyukhtikov flew it, or attempted to. Various changes made this aircraft marginally acceptable, but attempts to improve it ceased in 1937.

Again this was a wooden aircraft, with a skin of veneer (over the leading edge) and fabric. An innovation was to use aluminium to make the embryonic fuselage, which seated up to five, and the integral fin. The wing

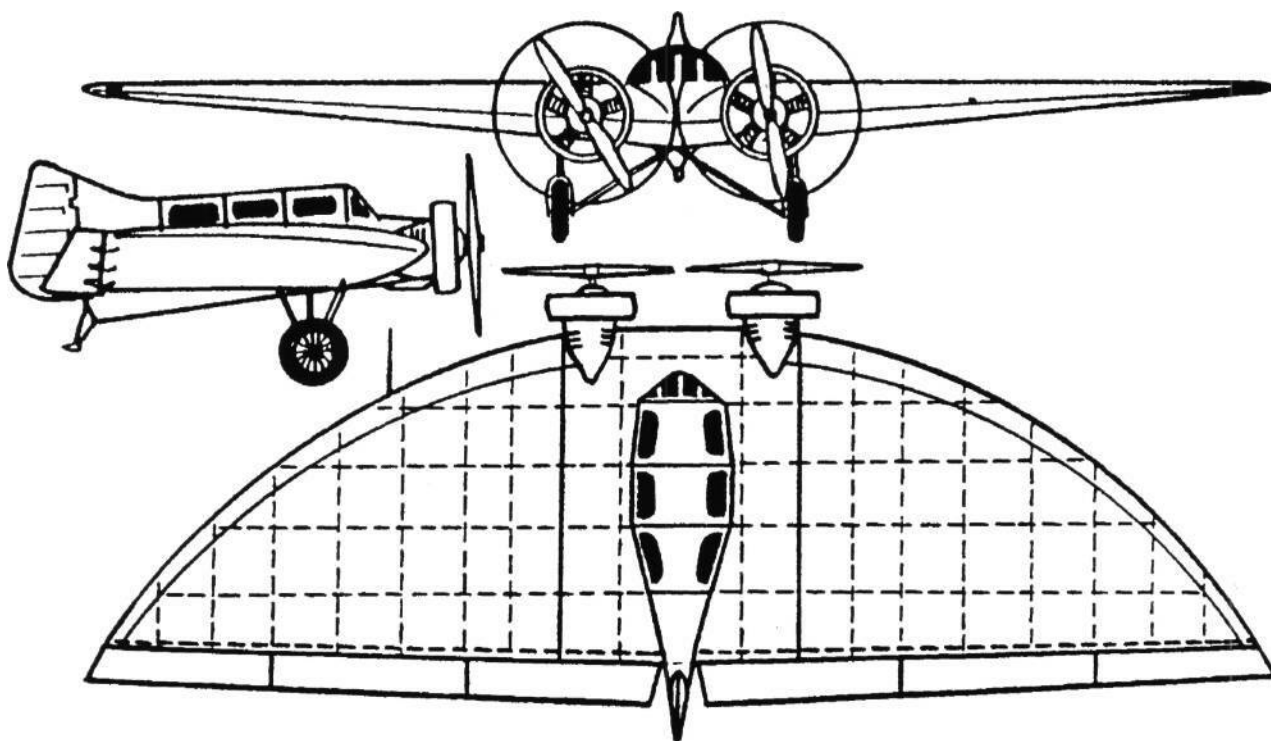
had four spars and 60 ribs, and was made as a centre section, of 3.3m (10ft 10in) span, and bolted outer panels. Close together on the leading edge were the two 100hp M-11 engines, with Townend-ring cowls, aluminium nacelles and U-2 type wooden propellers. As before, virtually all the development effort went into improving the trailing-edge controls, of which there were three on each wing, all hung in the usual Junkers style below the trailing edge. For most of the time the four inner surfaces were elevators and the outer surfaces were tested as flaps.

The BICH-14 apparently did nothing to enhance its designer's reputation.



BICH-14.

| | | |
|-----------------------|------------------|--------------------|
| Dimensions | | |
| Span | 16.2m | 53 ft 2 in |
| Length | 6.0m | 19 ft 9 in |
| Wing area | 60m ² | 646ft ² |
| Weights | | |
| Empty | 1,285kg | 2,833 lb |
| Loaded | 1,900kg | 4,189 lb |
| Performance | | |
| Maximum speed, approx | 220km/h | 137 mph |
| Range | 370km | 230 miles |
| Landing speed | 70km/h | 43.5 mph |



BICH-16

Purpose: To attempt to fly on human muscle power.

Design Bureau: B I Cheranovskii.

Ever one to explore fresh ideas, in 1934 Cheranovskii obtained financial support from Osoaviakhim (the Society of Friends of the Aviation and Chemical industries) for his pro-

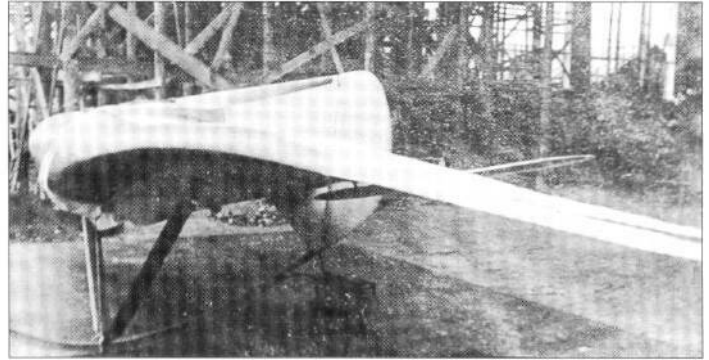
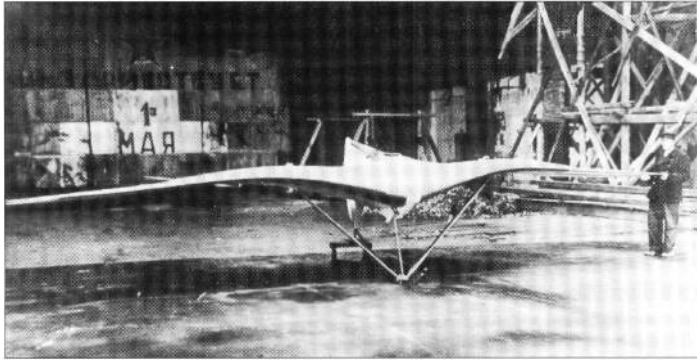
posal to build a man-powered ornithopter (flapping-wing aircraft). It could not be made to fly.

This bird-like machine consisted mainly of a flexible wing. The pilot placed his feet on a rudder bar directly under the rudder and then bent forward between two vestigial fins until he could grasp the spade-grip which, via the

two struts seen in the photo, flapped the wings. The two struts and vertical operating rod were pivoted at the bottom to a curved landing skid.

Data not recorded.

Two views of BICH-16.



BICH-17

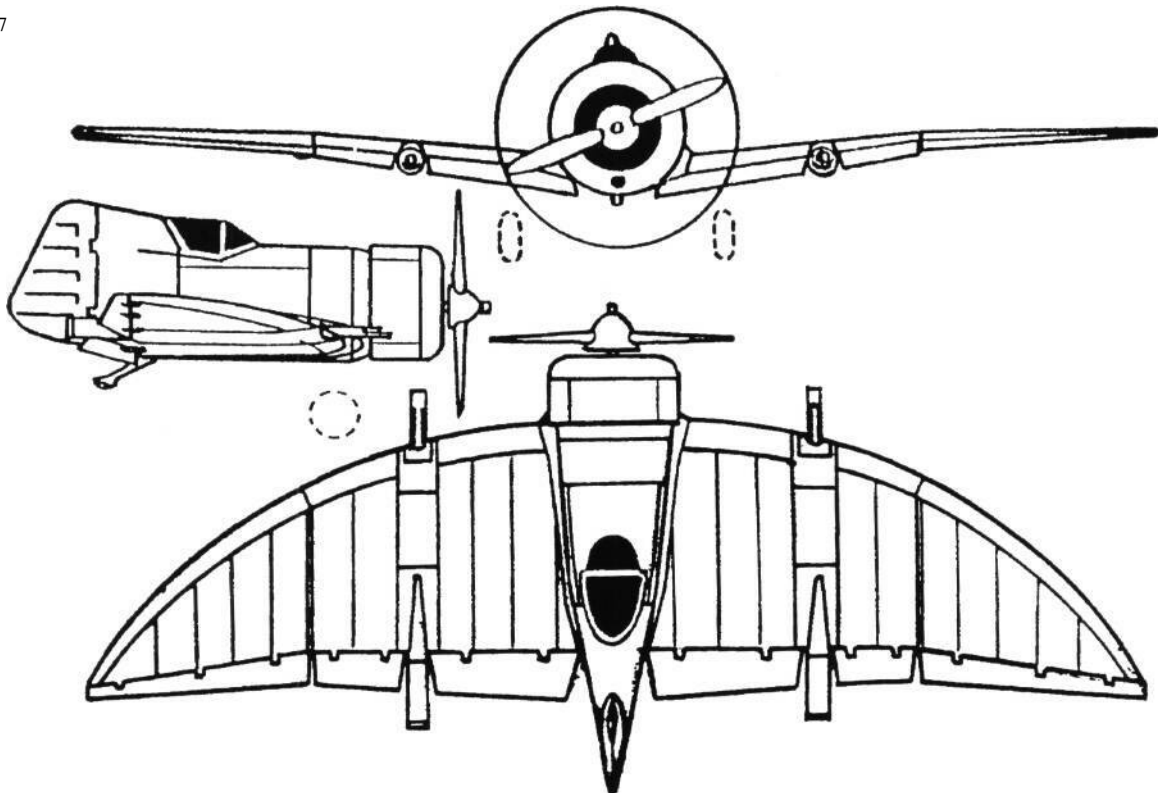
Purpose: Single-seat fighter.

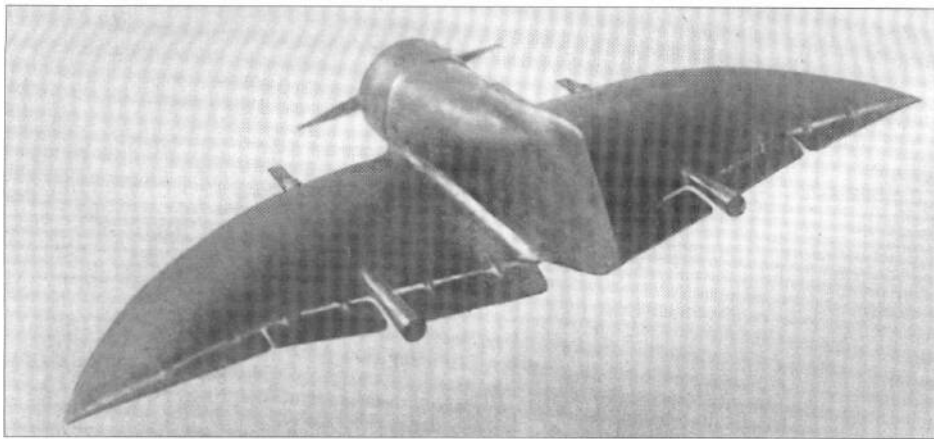
Design bureau: USP (Control of Special Work) organised by I B Kurchevskii, to which Cheranovskii was invited.

Kurchevskii was the designer of a family of APK and DRP recoilless guns of large calibre (45, 76.2, 80 and 100mm). These operated by firing a projectile down the barrel and a nearly equal mass plus gun gas from a rear nozzle. Fighters fitted with such guns included the

Grigorovich I-Z and Tupolev ANT-29 and ANT-46. Cheranovskii completed the design of the BICH-17 in 1935, but in February 1936 Kurchevskii was arrested and his design bureau 'liquidated'. By this time the BICH-17 was '60 per cent complete'.

BICH-17





Model of BICH-17.

No detailed documentation on this fighter survives, but the drawing shows that it was a typical Cheranovskii 'parabola' design. The structure was wood, with skins of birch shpon (multi-ply veneer), the wing having detachable outer panels. The engine was a 480hp M-22 (imported or licence-made Bristol Jupiter) driving a two-blade propeller. The main landing gears retracted, probably inwards, and the elevators were divided into inner and outer sections by the two 80mm APK guns. The pilot sat under a typical Cheranovskii upward-hinged canopy which formed the front part of the fin. Aircraft left incomplete.

BICH-18 Muskulyot

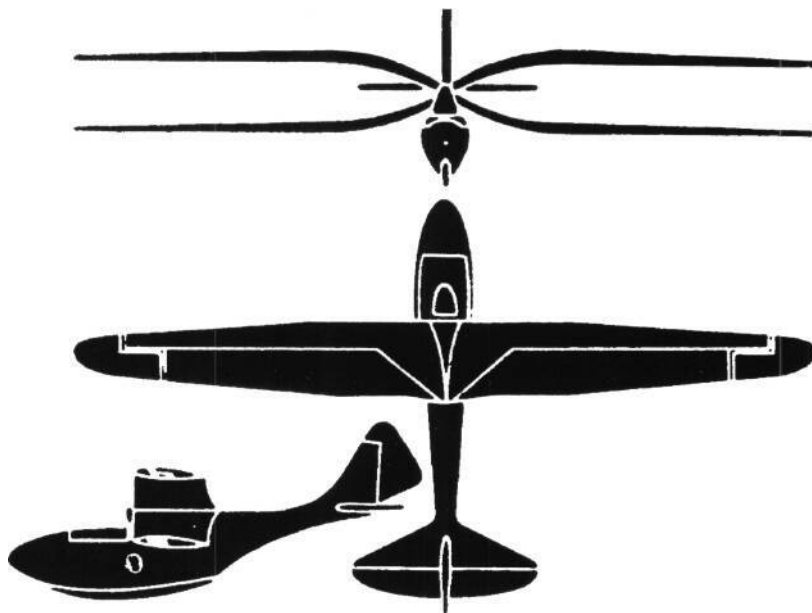
Purpose: To attempt once more to fly on human muscle power.

Design Bureau: B I Cheranovskii.

Undeterred by the total failure of BICH-16, Cheranovskii persevered with the idea of flying like a bird and designed the totally different BICH-18. The name meant 'muscle-power'. On 10th August 1937 pilot RA Pishchuchev, who weighed 58kg (128lb), glided 130m (426ft) off a bungee launch, without pedalling. He then did a pedalling flight, achieving six wing cycles. He reported 'noticeable forward thrust', and flew 450m (1,476ft). Sustained flight was considered impossible.

The BICH-18 vaguely resembled a performance sailplane with a cockpit in the nose and conventional tail. Much of the structure was balsa. There were two wing sets, comprising the lower left and upper right wings forming one unit and the upper left and lower right forming the other. Both sets were mounted on pivots on top of the fuselage and arranged to rock through a $\pm 5^\circ$ angle by cockpit pedals. As the wings rocked, their tips never quite touching, the portion of each wing aft of the main spar was free to flap up and down to give propulsive thrust. One report states that the outer trailing-edge portions were ailerons.

If the evidence is correct this odd machine was one of the few human-powered aircraft to have achieved anything prior to the 1960s.



BICH-18.



Dimensions

| | | |
|-----------|--------------------|--------------------|
| Span | 8.0m | 26 ft 3 in |
| Length | 4.48m | 14 ft 8 1/4 in |
| Wing area | 10.0m ² | 108ft ² |

Weights

| | | |
|--------|-------|--------|
| Empty | 72 kg | 159lb |
| Loaded | 130kg | 287 lb |

BICH-20 Pionyer

Purpose: To test a small sporting aircraft of tailless design.

Design bureau: B I Cheranovskii.

This attractive little machine was rolled out on skis in late 1937 and first flown in 1938. Later in that year it was fitted with a more powerful engine, and with wheel landing gear. Extensive testing, which included sustained turns at about 35° bank at different heights, showed that the BICH-20 was stable and controllable, and also could land very slowly.

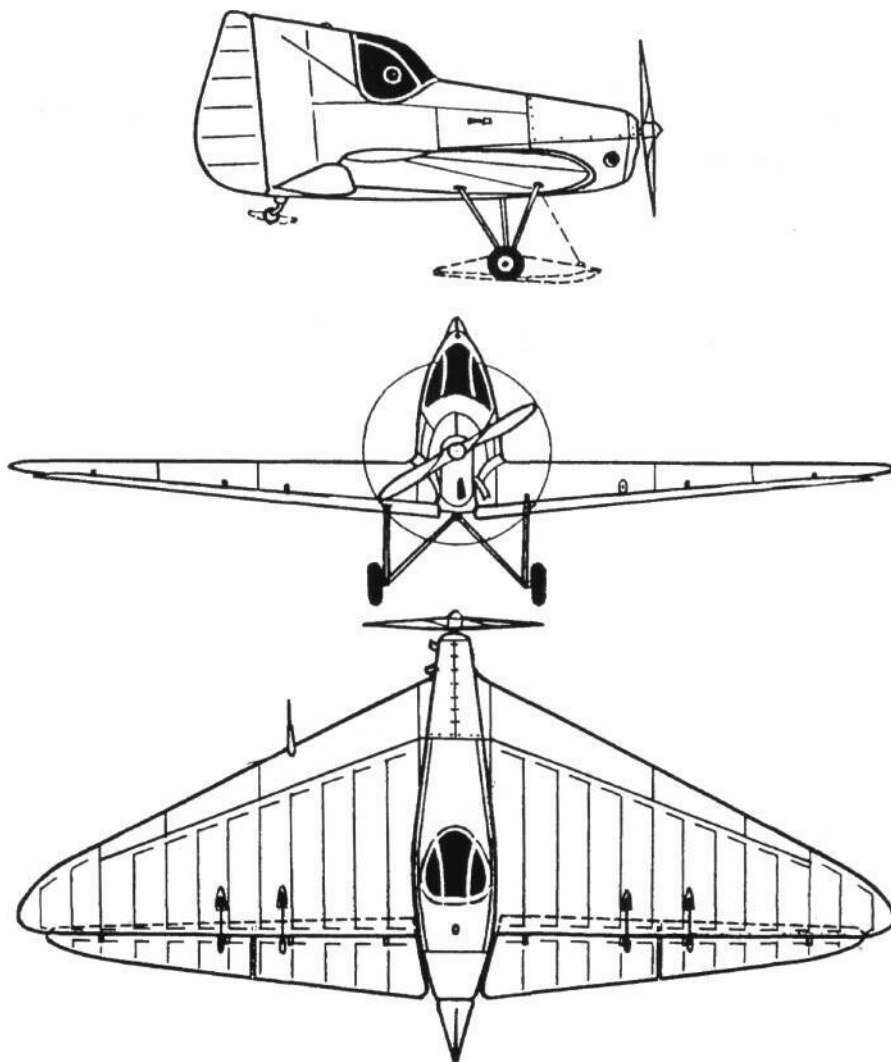
This aircraft was again a wooden structure, with ply over the leading edge and the vestigial fuselage. The wing marked a further change in aerodynamic form: having started with 'parabola' designs, Cheranovskii switched to delta (triangular) shapes, and with the BICH-20 adopted a more common form with straight taper, mainly on the leading edge. Trailing-edge controls comprised inboard elevators and outboard ailerons, with prominent operating levers. To enter the cockpit the pilot hinged over to one side the top of the fuselage and integral Plexiglas canopy which formed the leading edge of the fin. The aircraft was completed with Cheranovskii's ancient British 18hp Blackburne engine, in a metal cowl, and with sprung ski landing gear. It was later fitted with wheels, including a tailwheel, and a 20hp French Aubier-Dunne engine.

All known records suggest that this aircraft was completely successful.



BICH-20 Pionyer (Pioneer).

BICH-20

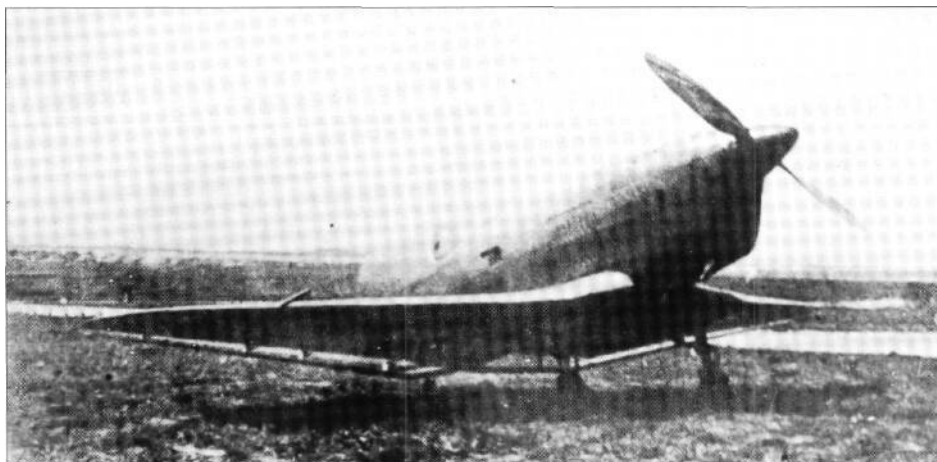


| Dimensions | | |
|------------------|--------------------|-------------------|
| Span | 6.9m | 22ft 8in |
| Length, original | 3.5m | 11ft 6in |
| re-engined | 3.56m | 11 ft 8in |
| Wing area | 9.0 m ² | 97ft ² |

| Weights | | |
|------------------|-------|--------|
| Empty, original | 176kg | 388lb |
| re-engined | 181kg | 399 lb |
| Loaded, original | 280kg | 617lb |
| re-engined | 287kg | 633 lb |

| Performance | | |
|-------------------------|---------|-----------|
| Maximum speed, original | 160km/h | 99 mph |
| re-engined | 166km/h | 103 mph |
| Service ceiling | 4,000 m | 13,120ft |
| Range | 320km | 199 miles |
| Landing speed | 49km/h | 30 mph |

BICH-21,SG-1



Purpose: To use the tailless concept in a more powerful aircraft for racing.

Design Bureau: B I Cheranovskii.

By the late 1930s Cheranovskii was confident that he could apply his unusual configuration, with no separate horizontal tail, to aircraft intended to reach much greater speeds. For the big All-Union race organised by Osoaviakhim to take place in August 1941 he designed a minimalist aircraft broadly like the BICH-20 but with a far more powerful engine. Also designated SG-1, from Samolyot Gonochnyi, aeroplane for racing, it was completed in 1940, but not flown until June 1941. The Ger-

BICH-21.

man invasion of 22nd June resulted in the race being cancelled.

With a configuration almost identical to that of the BICH-20, the BICH-21 was likewise all-wood, with polished shpon skin except over the metal engine cowl and cockpit canopy. Unlike the BICH-20 the wing was made as a centre section (with anhedral) and outer panels. This in turn resulted in a different arrangement of trailing-edge controls, these having reduced chord, with a significant portion ahead of the trailing edge of the wing, with the elevators divided into two

Dimensions

| | | |
|-----------|-------------------|------------------------|
| Span | 6.75m | 22 ft 8 in |
| Length | 4.74m | 15ft6 ³ /Un |
| Wing area | 9.0m ² | 97.0 ft ² |

Weights

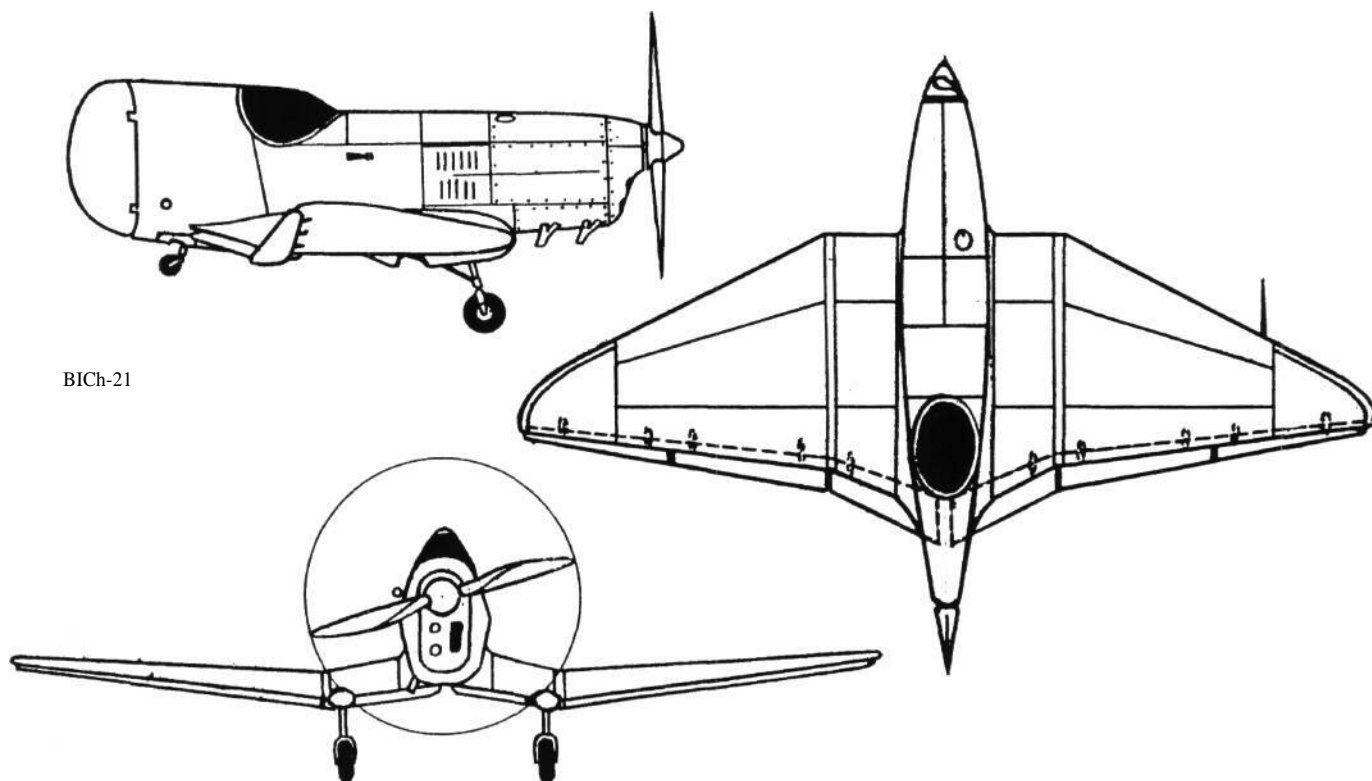
| | | |
|----------|-------|---------|
| Empty | 526kg | 1,160lb |
| Fuel/oil | 37kg | 81.6 lb |
| Loaded | 643kg | 1,418lb |

Performance

| | | |
|-------------------------|----------|---------|
| Max speed at sea level, | 385 km/h | 239 mph |
| at 4,000m (13,120 ft) | 417km/h | 259 mph |
| Landing speed | 80 km/h | 50 mph |

parts on each side. The engine was an MV-6, the Bessonov licence-built Renault with six aircooled cylinders, rated at 270hp. It drove an imported Ratier two-blade two-pitch (fine or coarse) propeller. A small fuel tank was inside each side of the centre section. Immediately outboard of these were the landing gears, which retracted backwards under pneumatic pressure.

No records survive of this aircraft's handling or of its fate.



BICH-21

BICH-22, Che-22

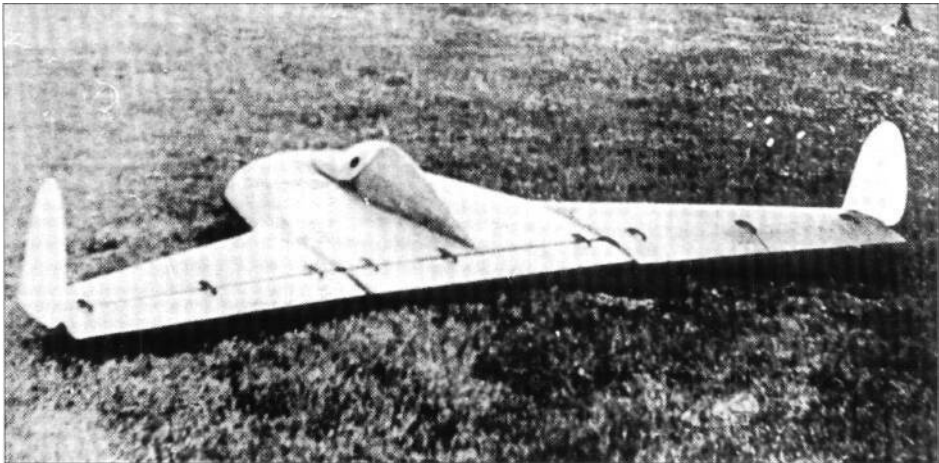
Purpose: To investigate a new aerodynamic configuration.

Design Bureau: B I Cheranovskii, by this time working at the MAI (Moscow Aviation Institute).

From 1947 Cheranovskii headed an OKB at the MAI, whose excellent facilities he used in a series of tailless projects. This glider was designed in winter 1948-49, and test flown by IA Petrov at Tushino from 17th July 1949.

Having progressed from the 'parabola' to a form of delta and then to a wing of normal tapered shape, this glider comprised a broad flat lifting fuselage, to which were attached conventional wings with modest sweepback. A further innovation was to use more conventional trailing-edge controls, mounted on the wing instead of below it. The original Che-22 drawings show no vertical surfaces whatever, but later fixed fins were added on the wingtips.

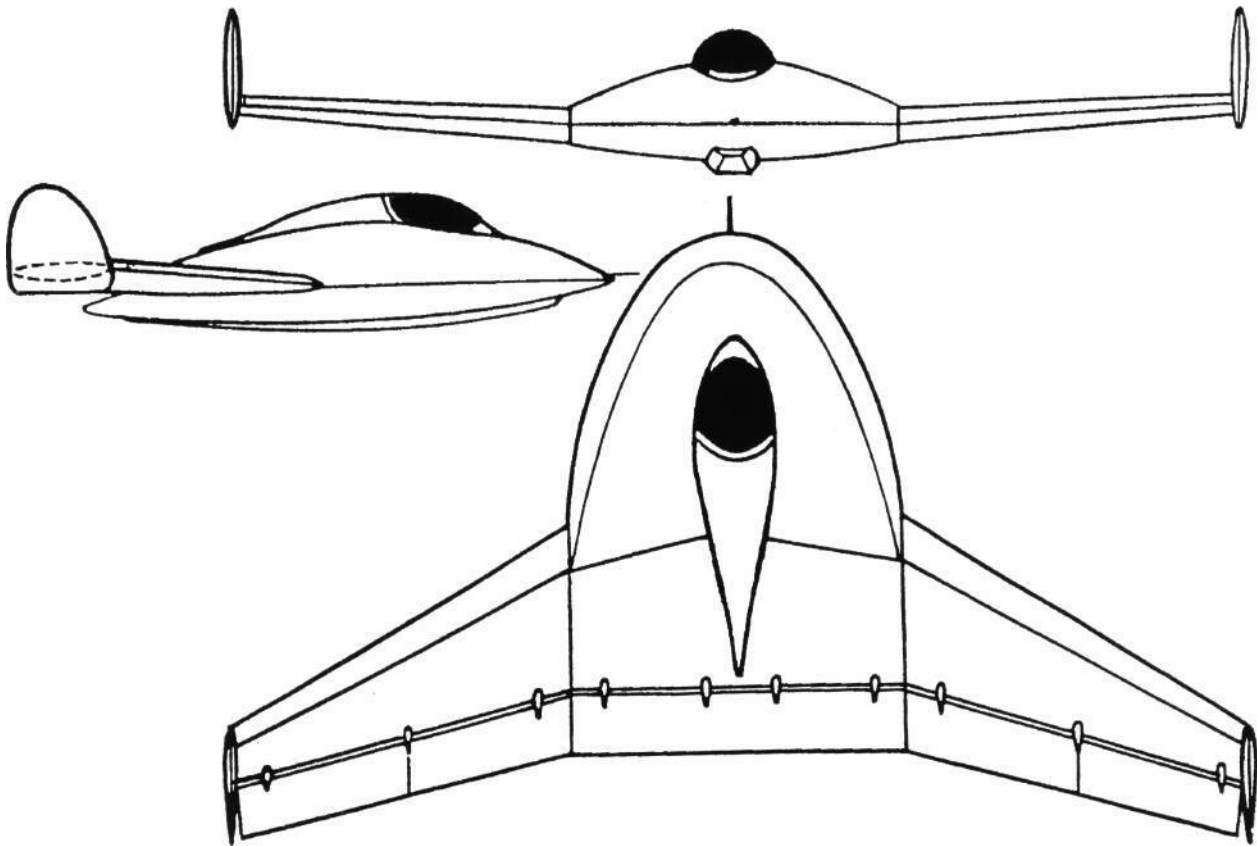
Flight testing appeared to go well, and in late 1949 the DOSAV repair shops tooled up to put the Che-22 into production. Unfortunately, while testing the first to come off the assembly line Petrov crashed and was killed, and production was abandoned.



| | | |
|--|-------|-------------|
| Dimensions | | |
| Span | 7.5 m | 24 ft 7½ in |
| Length | 5.04m | 16 ft 6¾ in |
| Wing area | 14mf | 151ft² |
| Weights | | |
| Empty | 60kg | 132lb |
| Performance | | |
| Not recorded, but 'aerodynamic efficiency' (lift/drag ratio) was 18. | | |

It is **not known if this is the full-scale Che-22 or a model.**

Che-22



BICH-24, (Che-24)

Purpose: To investigate the tailless delta configuration.

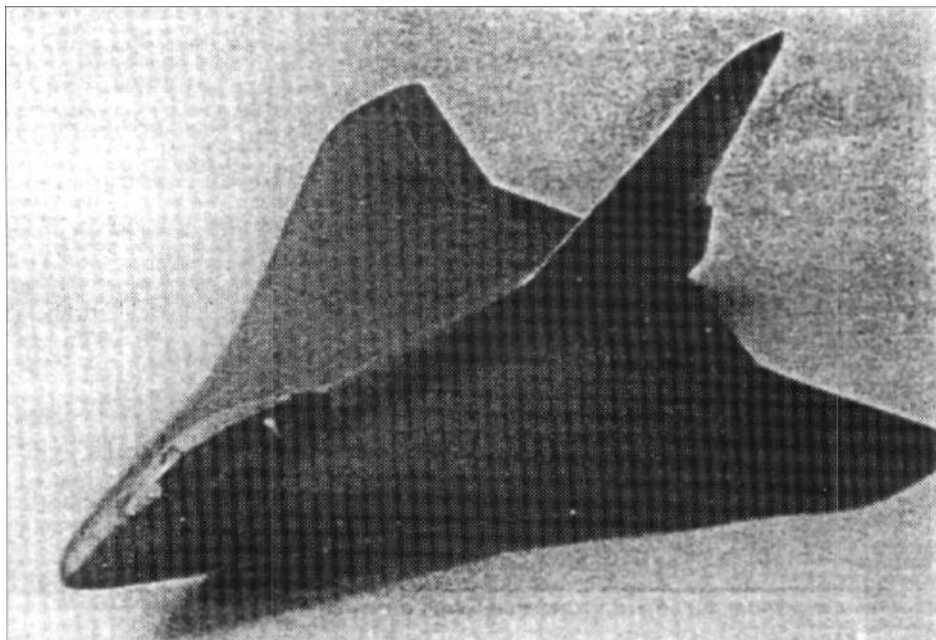
Design Bureau: B I Cheranovskii.

With the advent of the jet age Cheranovskii recognized that he should think in terms of much lower aspect ratio. He followed his 1944 project by the graceful BICH-24 jet fighter, which he hoped to demonstrate in the Tushino 'parade' of 1949. To prove its flying qualities he first tunnel-tested the model depicted.

Few details have been found, but the model picture reproduced here shows the configuration. Curiously, the documents on the BICH-24 call it the Che-24. No air intake is visible on the tunnel model, and it is not known whether the 24 would have been a turbojet or rocket aircraft.

It is not known if the full-scale aircraft was built.

Nodata.



BICH-24 (Che-24) model.

BICH-26, (Che-26)

Purpose: Jet fighter.

Design Bureau: B I Cheranovskii.

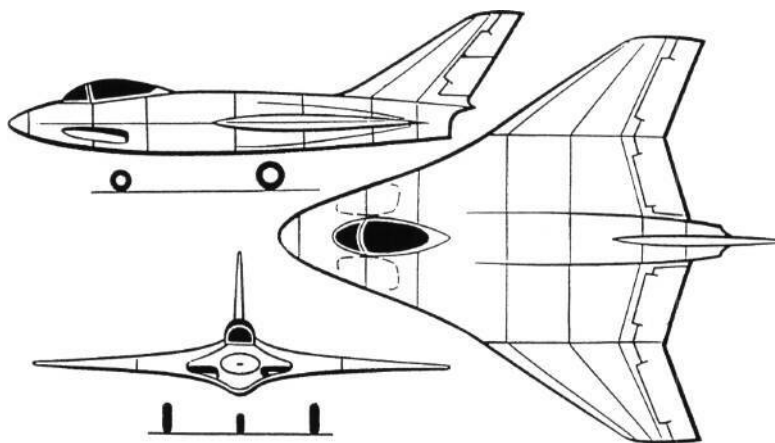
After the War Cheranovskii had an enhanced reputation, and he was able to build up a small team of designers to assist him with projects far more ambitious than those with which he made his name. In June 1948 the BICH-24 was followed by the BICH-25, a project for a jet fighter with variable-sweep wings with outboard pivots, uncannily like the American TFX projects of more than ten years

later. With the BICH-26 he returned to the BICH-24 formula with a fixed planform of almost delta, or gothic-delta, outline. Though Cheranovskii lived to the end of 1960 this project remained on the drawing board.

The BICH-26 was designed to have a single Mikulin (later Tumanskii) AM-5 turbojet rated at 2,000kg (4,409 lb) thrust, fed by flush inlets in the underside of the flattened forward fuselage. The latter could equally be described as the centre section of the wing, to which the conventional outer wings were attached. On

the trailing edge were inboard elevators and outboard ailerons, and though one report states that these surfaces were fully powered they all had deeply inset hinges for aerodynamic balance. There were also upper and lower rudders, again with inset hinges. No other details have appeared.

Like its various jet predecessors, the BICH-26 appears to have been an outstanding design with many features ahead of its time.



| | | |
|-----------------------------------|------------------|---------------------|
| Dimensions | | |
| Span about | 7.0m | 23ft |
| Length about | 9.0m | 29 ft 7 in |
| Wing area | 27m ² | 291 ft ² |
| Weights | | |
| Loaded | 4,500 kg | 9,921 lb |
| Performance | | |
| Maximum speed Mach 1.7 at 7,000 m | | 22,966ft |
| equivalent to about | 1,909km/h | 1,186 mph |
| Service ceiling | 22,000m | 72,000ft |

BICH-26 (Che-26)

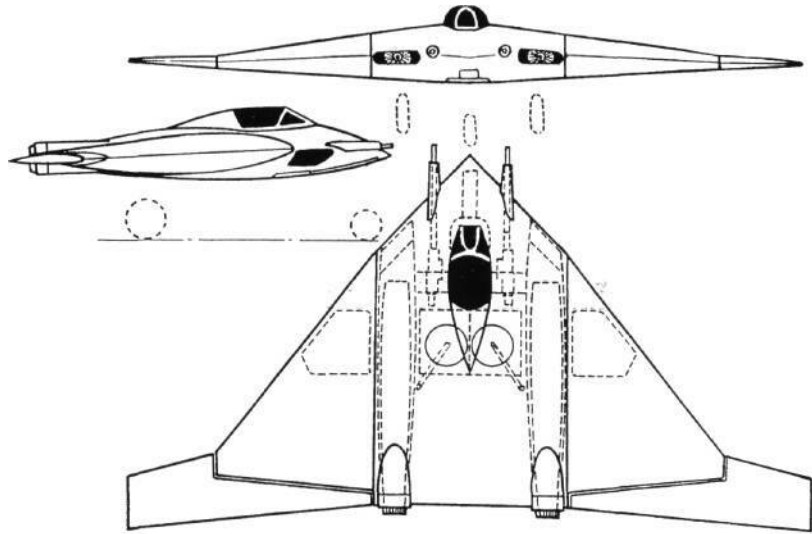
BICH jet project

Purpose: To design a jet fighter.

Design Bureau: B I Cheranovskii.

Again, the three-view drawing of this project was discovered only recently. There is no evidence that construction was even started. The drawing is dated 1944, at a time before any German turbojets had been captured but after publication of the existence of British and US engines of this type. The only turbojet then running in the Soviet Union was the Lyul'ka VRD-2, a slim axial-compressor engine rated at 700kg (1,543 lb) thrust. This was probably the engine Cheranovskii had in mind.

The configuration appears to be an outstanding one, similar to many fighter projects of the present day. The engines were to have been buried inside the broad and flat delta-shaped wing, there being no fuselage. The drawing shows the location of the cockpit, two large guns, nosewheel-type landing gear and four fuel tanks. Each wing carried a single control surface with a balancing area



ahead of the hinge. Clearly each surface acted as a dual-function elevator. There was no vertical tail, just like today's 'stealth' pro-

posals, and this could have made engine-out situations difficult.

A truly remarkable project. No data.

Bisnovat SK

Purpose: Experimental high-speed aircraft.

Design Bureau: OKB of Matus Ruvimovich Bisnovat, Moscow.

In the mid-1930s Bisnovat was working in the newly formed OKO of VKTairov (pronounced tyrov), at Kiev. In 1938 he was permitted to organise his own team of design engineers in order to build and test the fastest aircraft possible, for research into wing profiles, structures, flight controls and other problems. This was a time when aircraft technology was making rapid progress. Initially his production base was the Central Workshops of CAHI (TsAGI), but by 1939 this group was transferred to his own account.

Contracts were signed for two aircraft designated SK and SK-2. The former was to be the research aircraft, while the SK-2 was to have a conventional cockpit canopy and be capable of carrying armament and other military equipment. Surprisingly no documents appear to have been found recently giving details of this programme. All we have is Shavrov's Vol.2 (published 1978 but written much earlier) which says the SK 'was completed on skis in early 1939', and an article written in 1977 by Konstantin Kosminkov which says flight testing began 'at the start of 1940'. There is little doubt the latter date is correct. The first series of photographs, show-

ing the aircraft on its wheeled landing gear, are dated '20/1 40' (Roman I, ie January). The SK did not fly in this form until later, and flight testing began on non-retractable skis. The first photographs on skis were taken on '17/II 40'. Flight testing of the SK-2 began on 10th November 1940, and was completed on 10th January 1941. The pilot assigned to the programme was Georgi Mikhailovich Shiyanov.

The SK was a beautiful-looking low-wing monoplane of diminutive proportions (making the 1,050hp M-105 engine occupy nearly half the fuselage), entirely of light-alloy stressed-skin construction except for the fabric-covered ailerons and rudder. The wing was of NACA 23014.5 (14.5% thick) aerofoil profile, with wide-chord Vlasov (slotted split) flaps inboard of the ailerons. Structurally the wing was based on a Spitfire-like box with a heavy leading edge extending back to the single main spar. The ribs were Duralumin pressings. The outer surface (apparently of the wing only) was covered with marquisette (a fine light fabric) and powdered cork, all held by nitrocellulose glue. When fully set the surface was 'polished to the brilliance of a mirror'.

The small wing was made in one piece and designed so that it would be simple to fit different wings to the fuselage. The latter had a cross-section of only 0.85m² (9.15ft²), this

being the minimum to fit round the engine. The pilot sat in a reclining seat in a cockpit whose canopy was flush with the upper surface. For take-off and landing the roof over the rear half of the canopy could be hinged up and the seat raised to give a forward view. Drag was further reduced by using an engine cooling system filled with water circulating at a gauge pressure of 1.1kg/cm² (15.61b/in²), which enabled the frontal area of the radiator to be only 0.17m² (1.8ft²), half the normal size. The engine air inlet was underneath, ahead of the radiator, and the oil-cooler inlet on top. The propeller was a VISH-52 of 2.95m (9ft 5in) diameter, with three blades with constant-speed control. Other features included 100% mass balance on the elevators and rudder and, according to Kosminkov, a hydraulic system to operate the flaps, pilot seat, cockpit hood and the long-stroke (wheeled) landing gear, which retracted inwards into bays closed by multiple doors. The tailwheel was steerable and fully retractable. The standard of finish was high, and except for fabric areas the surface was polished, with the spinner, nose and a cheat-line painted red.

In fact, in 1939 retractable skis had not yet been developed, and for this reason the SK was initially limited to a modest speed (see data). So far as is known the SK flew well, though Shavrov records that the SK-2 (and by

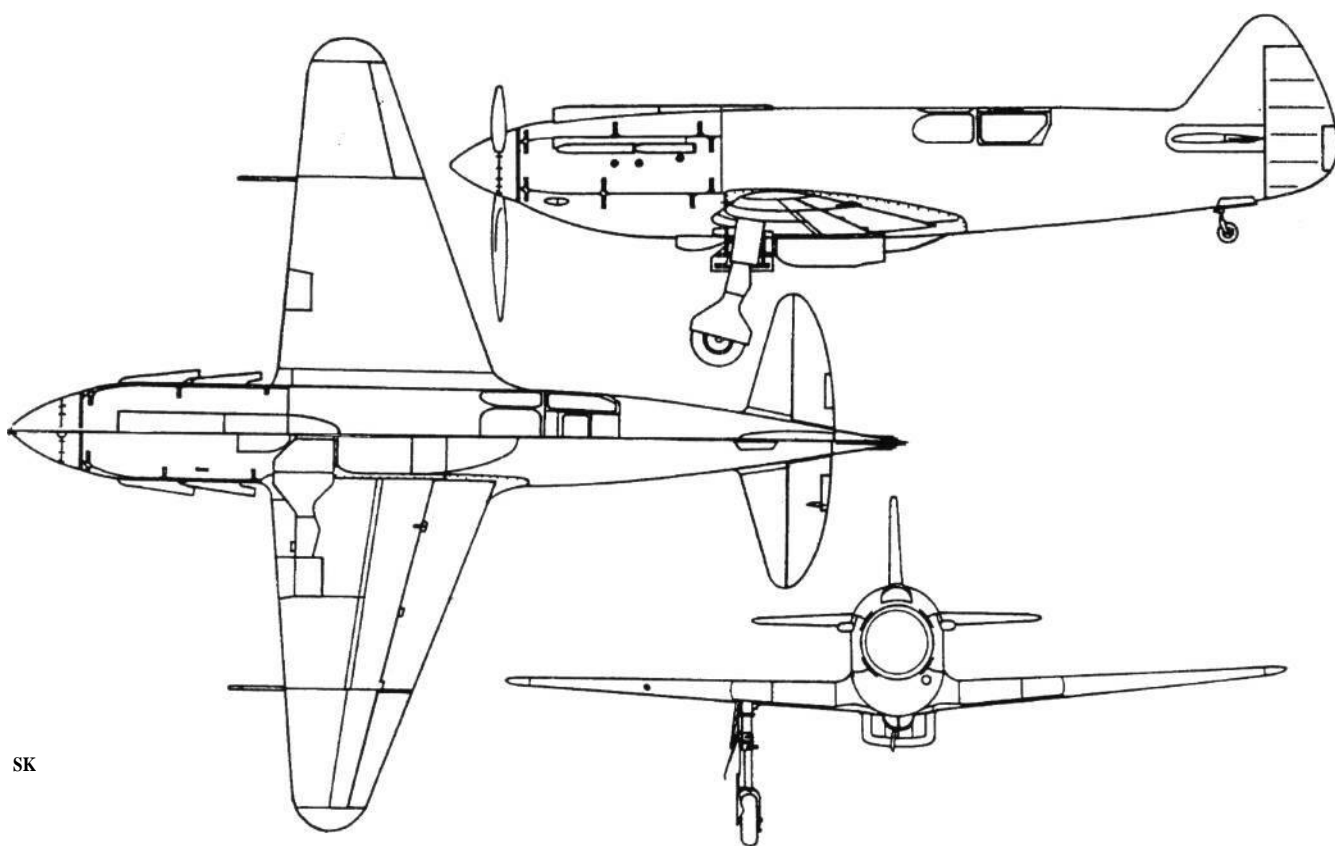
implication the SK) suffered from various defects which prevented it from being accepted as a fighter.

Compared with the SK, the SK-2 differed most obviously in having a normal cockpit, with a fixed more upright seat and conventional canopy, which could be jettisoned, with a sliding window on the left. The engine installation was modified, with a reprofiled coolant radiator, engine air inlets in the wing roots and the oil cooler under the cowling. This left the area above the engine clear for a neat installation of two 12.7mm BS heavy machine guns with their magazines (Kosminkov states there was a 7.62mm as well). The SK-2

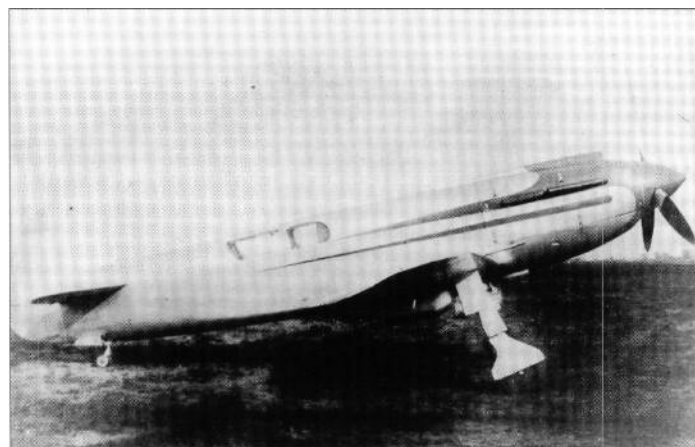
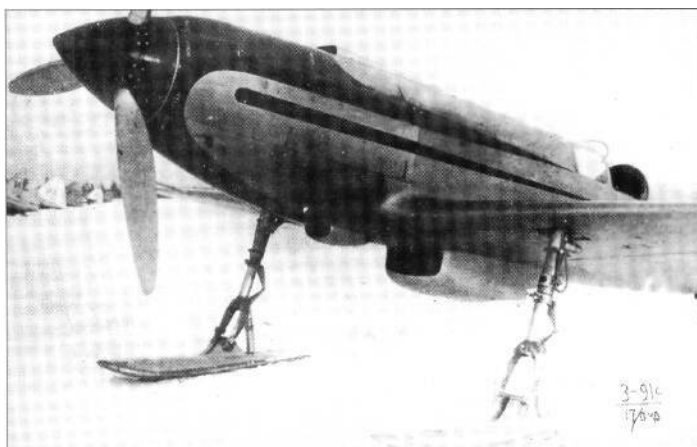
airframe was slightly modified, notably by increasing the height of the fin and the span of the horizontal tail from 2.75m (9ft 4in) to 3.26m (10ft 8in). This aircraft was painted overall, in a deep colour.

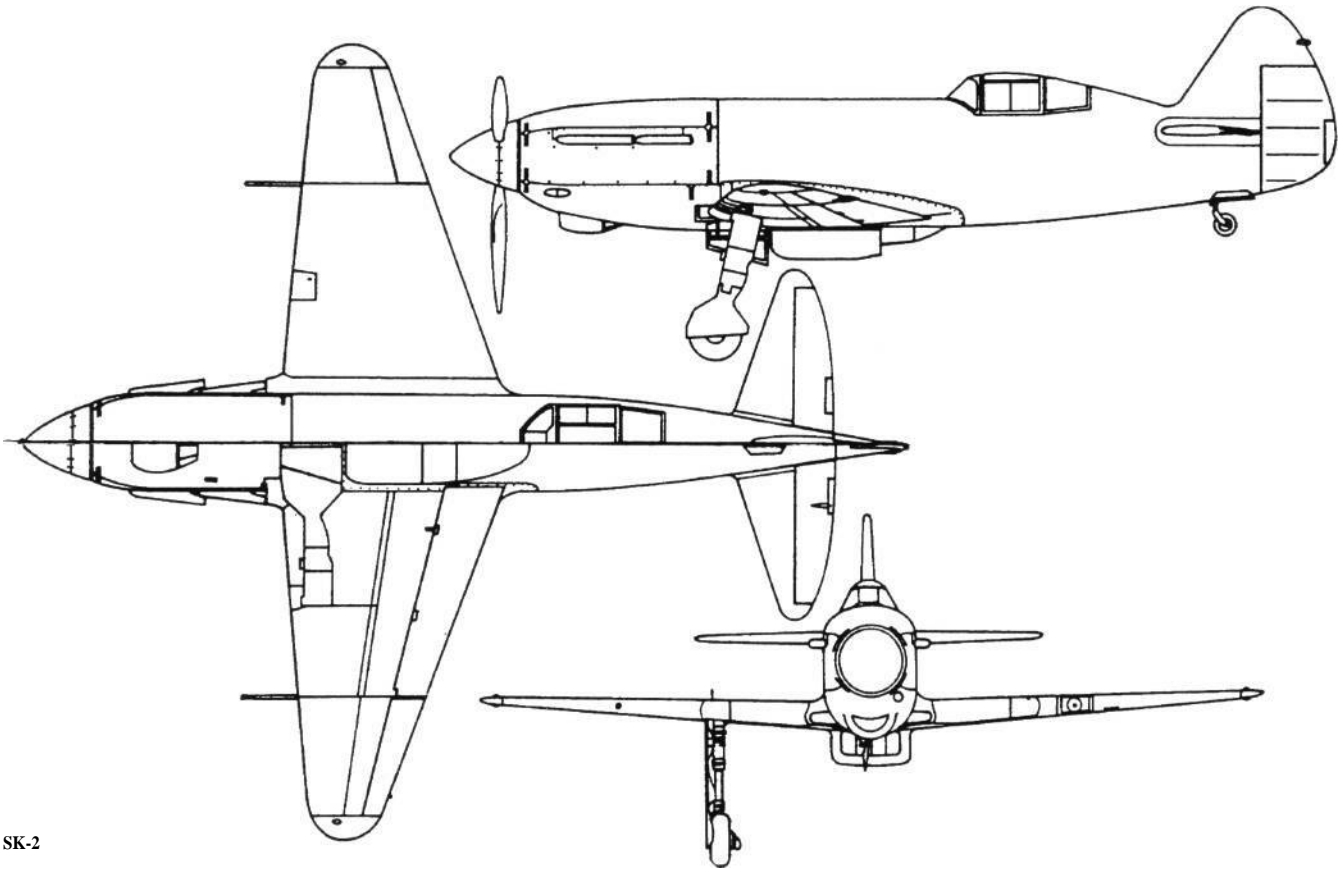
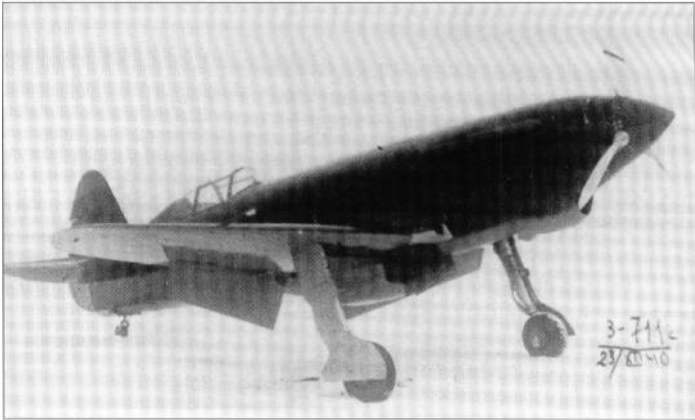
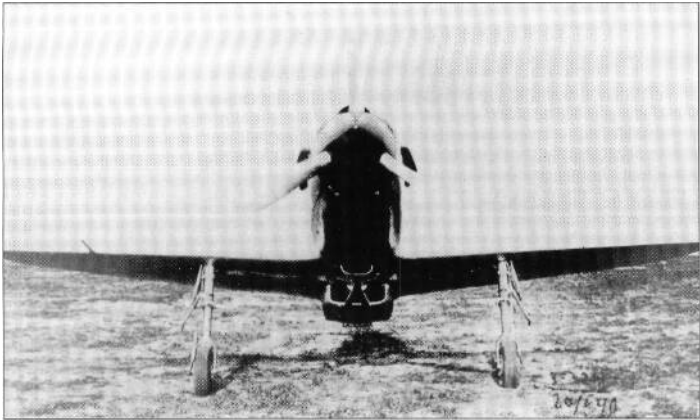
In 1940 these aircraft were the fastest in the Soviet Union, and probably in the world. Despite their 'hot' nature, and high wing loading, they appear to have been safe and attractive machines. However, with so many La, MiG and Yak fighters already in production, the SK-2 had little chance of being adopted as a fighter.

| Dimensions (SK) | | |
|------------------------------|---------------------|---------------------|
| Span | 7.3m | 23 ft m in |
| Length | 8.28m | 27 ft 2 in |
| Wing area | 9.57 m ² | 103 ft ² |
| Weights | | |
| Empty | 1,505kg | 3,318 lb |
| Loaded | 2,100kg | 4,630 lb |
| Performance | | |
| Max speed (wheels) | | |
| at sea level, | 597km/h | 371 mph |
| at 5,250m (17,224ft) | 710km/h | 441 mph |
| (skis) at 5,500m (18,045 ft) | 577km/h | 358.5 mph |
| Service ceiling | 10,450m | 34,285 ft |
| Range about | 1,000km | 621 miles |



SK





SK-2

Top left and right: Two views of SK-2 (on right, note split flaps).

| | | |
|--------------------------|--------------------|--------------------|
| Dimensions (SK-2) | | |
| Span | 7.3m | 23 ft11 in |
| Length | 8.285m | 27 ft 214 in |
| Wing area | 9.57m ² | 103ft ² |
| Weight | | |
| Empty | 1,850kg | 4,078 lb |
| Loaded | 2,300kg | 5,071 lb |
| Performance | | |
| Max speed at sea level | 585km/h | 363.5 mph |
| at 5,500m (18,045 ft) | 665km/h | 413 mph |
| Time to climb to 5,000 m | 4min 19secs | (16,404ft) |
| service ceiling | 10,300m | 33,793ft |
| Take-off run | 350m | 1,148ft |
| Landing speed/ run | 168km/h | 104 mph |
| | 500m | 1,640ft |

Opposite page: SK on skis and on wheels.

BOK-1, SS

Purpose: To investigate high-altitude flight, and if possible set records.

Design Bureau: The Byuro Osobykh Konstruktsii, the Bureau of Special Design, Smolensk. BOK was formed in 1930 in Moscow as a subsidiary of CAHI (TsAGI) to build experimental aircraft ordered by the Revolutionary Military Council. Despite starting on existing projects it made slow progress, and in September 1931 was transferred to the CCB (TsKB) as Brigade No 6. It had undergone other transformations, and been relocated at Smolensk, by the time work began on BOK-1. Director and Chief Designer was Vladimir Antonovich Chizhevskii.

One of the bureau's first assignments was to create an aircraft to explore flight at extreme altitudes, seen as 'No1 priority'. Close links between the USSR and Junkers resulted in BOK sending a team to Dessau in 1932 to

study the Ju 49, and in particular its pressurized cabin. This strongly influenced their thinking, and led to many studies for a Soviet counterpart, but the only hardware built was the balloon SSSR-1, with a pressurized gondola, which in 1933 exceeded 18km (59,055ft). In 1934 a major conference of the Academy of Sciences issued a programme for future research, one requirement being a high-altitude aircraft. The contract for the SS (Stratosfernyi Samolyot, stratospheric aeroplane) was signed with BOK.

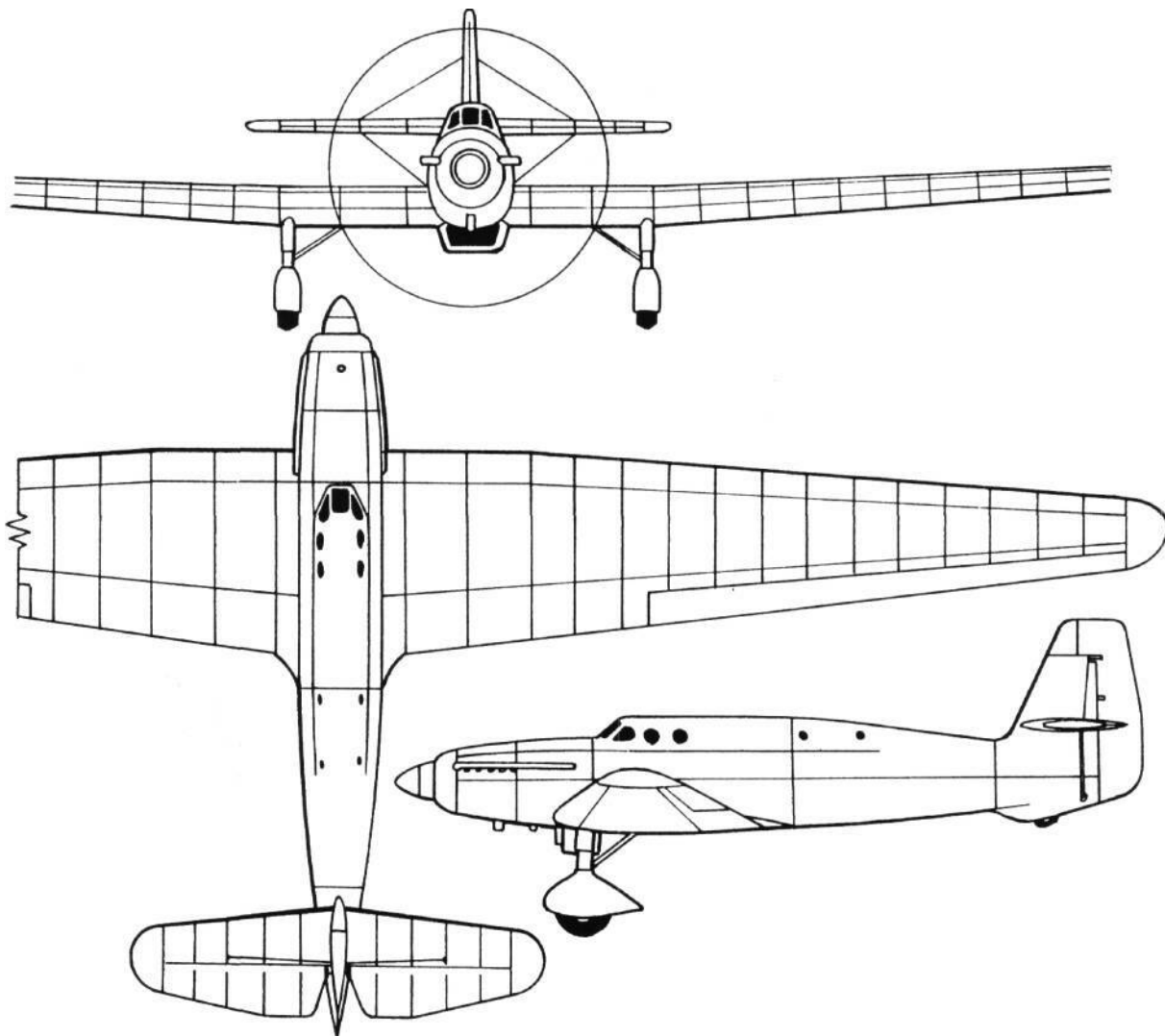
By this time Tupolev had designed the long-range RD (ANT-25), and to save time BOK used this as the basis for the BOK-1. The main task was to design the pressure cabin, but there were many other major modifications. The BOK-1 was built at GAZ (State Aircraft Factory) No 35 at Smolensk, where it was first flown by I F Petrov in (it is believed, in September) 1936. It was repeatedly modified in order to climb higher. It was successfully put

through GOSNII-GVF State testing by PM Stefanovskii. Shavrov speaks of 'a lighter variant' achieving greater heights, but there is no evidence of a second BOK-1 having been built.

The airframe was originally that of one of the military RD aircraft, but modified by GAZ No 35. The span was reduced by fitting new constant-taper outer panels, restressed for significantly reduced gross weight achieved by greatly reducing the fuel capacity. The massive retractable twin-wheel main landing gears were replaced by lighter fixed units with spatted single wheels. The engine was an AM-34RN liquid-cooled V-12, rated at 725hp, driving a three-blade fixed-pitch propeller.

The main new feature was the pressure cabin, seating the pilot and a backseater who acted as observer, navigator and radio operator (though no radio was ever installed). This cabin was a sealed drum of oval cross-section, with closely spaced frames to bear the

BOK-1



bursting stress, constructed of D1 light alloy with 1.8 or 2.0mm skin riveted over a sealing compound. Design dP (pressure differential) was 0.22kg/cm² (3.2 lb/in²). The front and rear were sealed by convex bulkheads. The entry hatch was at the rear and an escape hatch was provided in the roof. One report says there was no room for parachutes, which were stowed in the rear fuselage. There were five small glazed portholes for the pilot and one on each side ahead of the backseater. There were also four small portholes to admit light to the unpressurized rear fuselage. A regenerative system circulated the cabin air and removed carbon dioxide (one report says 'and nitrogen'). A controlled leak through a dump valve was made good by oxygen from bottles to keep oxygen content approximately constant. The engine cooling circuit heated a radiator covering the cabin floor to keep internal temperature at 15-18°C.

Flight testing revealed satisfactory flying characteristics and a lack of vibration. On the other hand, on any prolonged flight the cabin became uncomfortably hot. Despite this, and electric heating of the portholes, the glazed surfaces quickly misted over. In any case, external vision was judged dangerously inadequate.

Shavrov states that the cabin was qualified for flight to '8,000m and more'; this is ambiguous, and the original design objective was that the interior should be equivalent to an altitude of 8,000m (26,250ft) at the design ceiling of the aircraft. The engine cooling circuit was modified, and the portholes were replaced by double-layer sandwiches with not only electric heating but also a dessicant (moisture absorber) between the panes. This overcame the condensation, but nothing could be done to improve field of view.

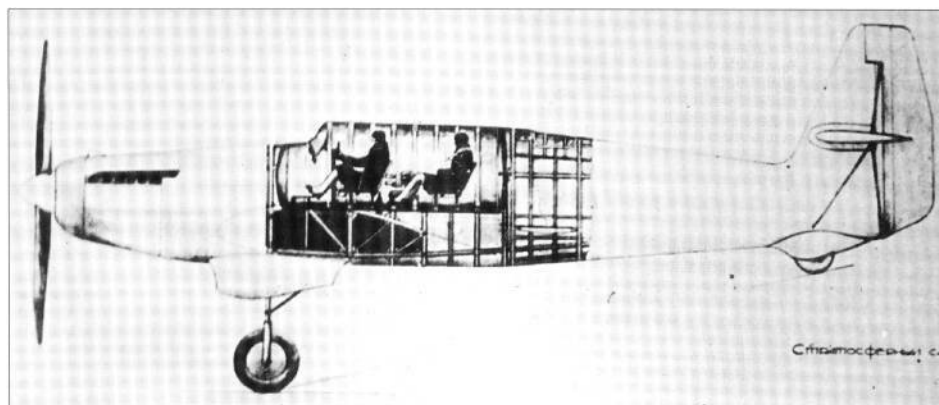
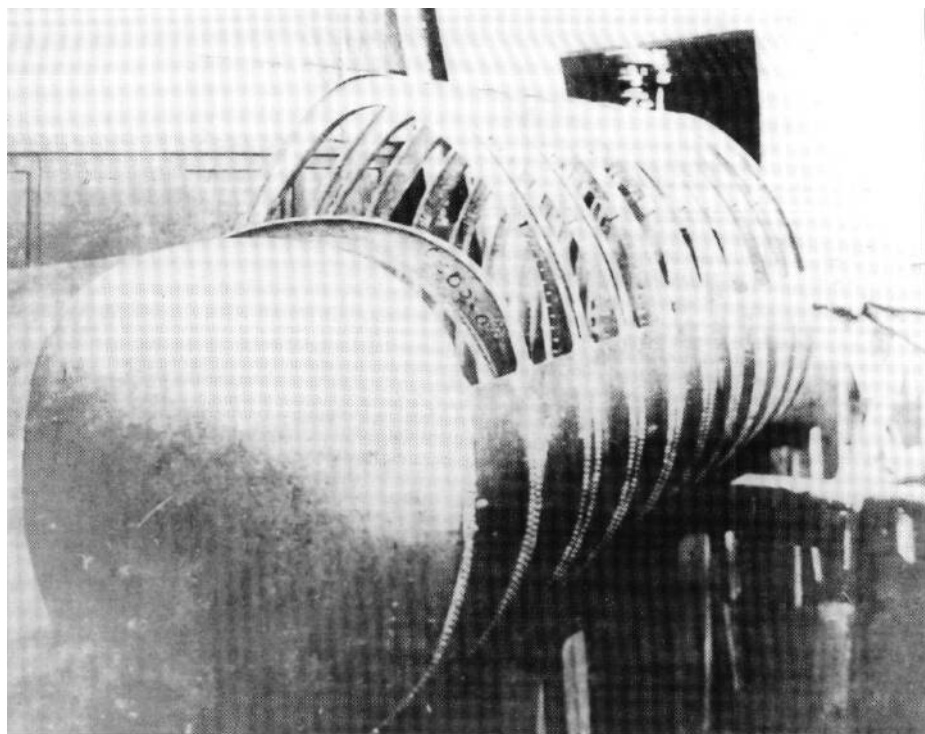
In spring 1937 the BOK-1 was fitted with an 830hp M-34RNV engine, driving a four-blade fixed-pitch propeller. This engine was then fitted with two TK-1 turbosuperchargers, designed by VI Dmitriyevskiy so that the combined turbo exhausts also added a thrust of 70kg (154lb). With the new engine installation the altitude performance was much improved (see data), but during an attempt to set a record for height reached with 500 and 1,000kg payload one of the turbos blew up. Shavrov says merely 'the attempt failed', but another account says the exploding turbo seriously damaged the forward fuselage and resulted in the BOK-1 being scrapped.

The BOK-1 was only the second aeroplane in the world to be designed with a pressure cabin. It achieved most of its objectives, but failed to set any records.

Top: BOK-1 pressure cabin.

Centre: BOK-1 inboard profile.

Bottom: BOK-1 (final form).



| Dimensions | | | Performance | | |
|-----------------------|-----------------------|---------------------|--------------------------|----------|-------------|
| Span | 30.0m | 98 ft 5 in | Max speed at sea level | 210km/h | 130 mph |
| Length | 12.86m | 42 ft 7 in | at 4,000m, (13,123 ft) | 242km/h | 150 mph |
| Wing area | 78.8m ² | 848 ft ² | (after engine change) | 260 km/h | 162 mph |
| Weights | | | Time to climb to 5,000 m | 15 min | (16,404ft) |
| | Empty (as built) | 3,482 kg | to 9,000m | 38 min | (29,528 ft) |
| | (after engine change) | 3,600 kg | Ceiling | 10,700m | 35,100ft |
| Fuel | 500kg | 1,102lb | (after engine change) | 14,100m | 46,260 ft |
| (after engine change) | 1,000kg | 2,205lb | Endurance (both states) | 4 hours | |
| Loaded | 4,162kg | 9,175lb | | | |
| (after engine change) | 4,800kg | 10,582 lb | | | |

BOK-2, RK

Purpose: To test designer's experimental wing.

Design Bureau: Aircraft constructed by BOK to design of S S Krichevskii.

Sawa Syemenovich Krichevskii, called 'a talented designer' by historian Shavrov, spent the early 1930s trying to create the most efficient aeroplane wing. He made many tunnel models, eventually settling on a wing of high aspect ratio constructed in front and rear sections. The rear part was hinged to the front

with a small intervening gap acting as a slot. In flight, the intention was that the pilot would select the optimum angle for the rear portion, Shavrov commenting that 'this wing could always be flown in a drag-polar envelope'.

Krichevskii secured funding to build a research aircraft, called RK (Razreznoye Krylo, slotted wing) and designated BOK-2 by the construction bureau. The BOK-2 was completed in 1935 and flew successfully, but Krichevskii died shortly afterwards. Documentation on this aircraft has never been found.

The BOK-2 was an extremely neat cantilever monoplane, with a single M-11 engine rated at 11 Ohp. Shavrov comments that 'The wing skin was polished to mirror brilliance [suggesting all-metal construction]...it is hard to say if its excellent performance was due to its drag-polar envelope or to its perfect aerodynamic shape'.

Despite its apparently excellent performance the RK appears to have had no impact on the Soviet aviation ministry.

No data available.

BOK-5

Purpose: To experiment with a tailless (so-called 'flying wing') design.

Design Bureau: Bureau of Special Design, Smolensk. Design team led by V A Chizhevskii.

The idea for this small research aircraft came from the BOK-2, though the two aircraft were completely unrelated. In 1935 Chizhevskii began studying tailless aircraft, and obtained funding to build a simple research aircraft. This was completed in early 1937, but was then modified and did not fly until September, the pilot being I F Petrov. It 'flew satisfactorily...but crashed during a landing'. After being repaired and modified its handling qualities were greatly improved. In 1938 the

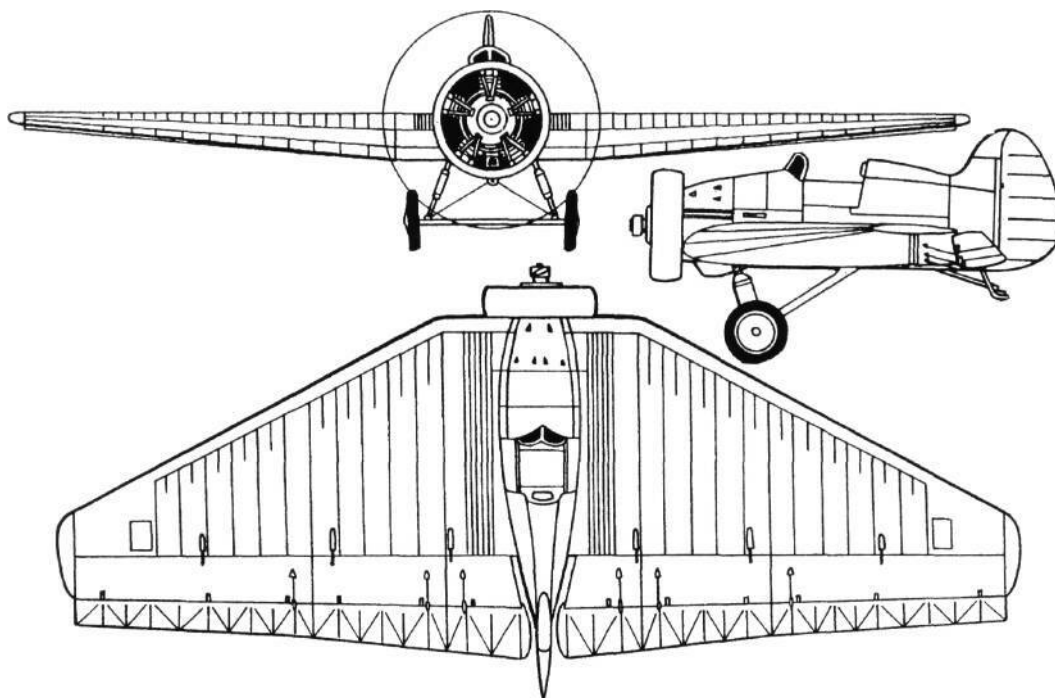
modified aircraft was tested by the Nil WS (air force flight-test institute), where it was flown by such pilots at P M Stefanovskii and M A Nyukhtikov. Stefanovskii is reported to have said that the BOK-5 could be 'flown by pilots of average or even below average ability' and to have been 'impressed by its acrobatic capability'.

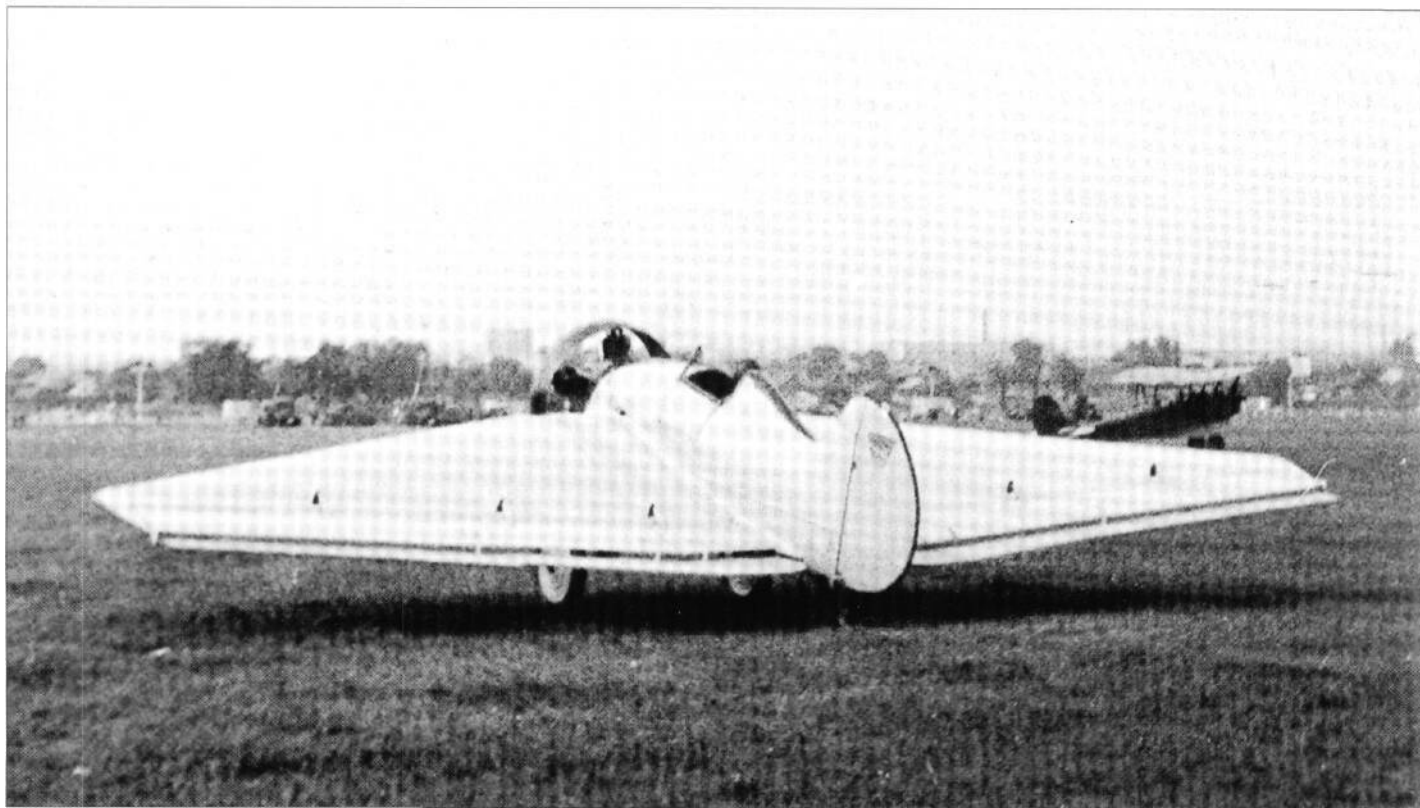
The BOK-5 was a basically simple aircraft, apart from the flight-control system. The airframe was made of duralumin. The wing was of CAHI (TsAGI) 890/15 profile (15 per cent t/c ratio), with two spars with tubular booms and sheet webs, and ribs assembled from channel and angle sections, with fabric covering. The short fuselage was a semi-monocoque, with some box-section longerons and

pressed-sheet frames, the vertical tail being integral. The main landing gears were described as 'U-2 type'. On the nose was a 100hp M-11 engine in a Townend-ring cowl, driving a two-blade metal propeller.

Modifications concentrated on the trailing-edge controls. According to Shavrov there were three movable surfaces on each wing, extending over 21 per cent of the chord. The outermost was a rectangular aileron, and the two inboard surfaces acted in unison as elevators. Most photographs and drawings show these surfaces as simple one-piece units hinged to brackets below the trailing edge and with a neutral setting of -5°. However, recently a drawing (reproduced here) was discovered showing the main surfaces operated

BOK-5





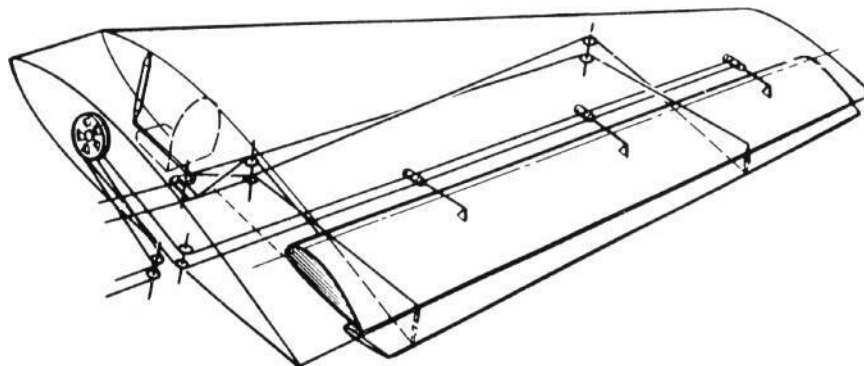
by servo action. The pilot's control cables can be seen to drive a narrow-chord servo control which in turn moves the main surface. The neutral setting of the main surfaces can be seen to be adjusted by a longitudinal-trim wheel with cables to screw-jacks.

The BOK-5 was clearly a safe aircraft which impressed two of the Soviet Union's best test pilots, but it remained a one-off which was soon forgotten.

| Dimensions | | |
|------------|---------------------|--|
| Span | 9.86m | 32 ft 4 ¹ / ₂ in |
| Length | 4.365m | 14 ft 4 in |
| Wing area | 23.15m ² | 249ft ² |

| Weights | | |
|---------|-------|----------|
| Empty | 596kg | 1,314 lb |
| Fuel | 90kg | 198 lb |
| Loaded | 764kg | 1,684lb |

| Performance | | |
|-----------------------|----------------|-----------------|
| Maximum speed | 174km/h | 108 mph |
| Take-off run | 120m | 394ft |
| Service ceiling | 4,850 m | 15,900ft |
| Range | 600km | 373miles |
| Endurance | 4 hours | |
| Landing speed/ run | 85km/h 200m | 53 mph 656ft |



Top and centre: Two views of BOK-5.

Bottom: BOK-5 servo control.

BOK-7, K-17

Purpose: To continue stratospheric-flight research with an aircraft superior to BOK-1.

Design Bureau: Bureau of Special Design, Smolensk. Chief designer Chizhevskii.

Design of this aircraft began in 1936. The Tupolev RD was again used as the starting point, but with features intended to enable greater heights to be reached. The test pilots were Petrov and Stefanovskii. According to Shavrov the BOK-7 was first flown in 1938, and 'showed the same characteristics as the BOK-1'. Several two-man crews, including such important long-distance pilots as Gromov, Yumashev, Danilin, Spirin, Baidukov, Belyakov and others, spent periods of several days sealed in the GK checking all aspects of human life in preparation for proposed high-altitude long-distance flights in the BOK-15. According to some historians the ultimate objective was a high-altitude circumnavigation, and that the by-function designation of this aircraft was K-17, from Krugosvetnyi (round the world). Photographs originally thought to be of the BOK-7 are now known to show the BOK-11.

The BOK-7 had the full-span wing of the RD, and aft-retracting landing gears, but compared with the RD the legs were redesigned for much lighter gross weight, and fitted with single wheels. Attention was concentrated on the fuselage, which unlike the BOK-1 had the GK (pressure cabin) integral with the airframe, the centre fuselage being a slim cylinder sealed by gaskets and adhesives, and with grommets fitting round the control wires and other services passing through apertures in the wall. The normal oxygen supply to the pilot and pilot/observer 'compensated for the insignificant amount of air escaping'. The sealed drum was fitted with two hemispherical domes, the front with eight and the rear with six transparent portholes so that the occupants could see out, with a better view than from the BOK-1. The GK was kept at pressure by a tapping from a centrifugal PTsN (supercharger) blower driven by step-up gears from the engine. The engine was an 890hp M-34FRN fitted with two TK (turbosuperchargers). It is probable that these delivered compressed air to the PTsN which then fed the engine, the cabin supply being taken off a

small bleed pipe. Shavrov states that 'all systems worked well', and that the experiments were 'very interesting'.

According to Shavrov this aircraft had 'the first GK of the combined type' with both a sealed compartment kept under pressure and an oxygen supply. Some accounts state that AI Filin at the NII-WS worked out details of the proposed circumnavigation, in 100-hour stages, but that the project was abandoned after he was arrested in 1939 and executed in Stalin's Terror of 1940. This aircraft led to the BOK-8, BOK-11 and BOK-15, but it appears that no illustrations of it have been discovered.

| Dimensions | | |
|----------------|------------------|-----------------------|
| Span | 34.0m | 111 ft W in |
| Length | 12.9m | 42 ft 4 in |
| Wing area | 87m ² | 936.5 ft ² |
| Weights | | |
| Empty | 3,900kg | 8,598 lb |
| No other data. | | |

BOK-8

Purpose: To devise an armament system for the BOK-11.

Design Bureau: Bureau of Special Design, Smolensk.

In 1937 the BOK began work on the BOK-11 (see below) and decided that it should have defensive armament. The BOK-8 was schemed to test this armament. Design was entrusted to BOK engineers V S Kostyshkin

and K B Zhbanov. The complete installation was on test by December 1939. Few details have survived, and the aircraft never flew.

The armament system comprised two power-driven barbettes or turrets each housing guns (one report says cannon but Shavrov says 'machine guns') outside the pressure cabin, aimed by a synchronous tracking system with thyatron servo control. The gunner, to have been the third member of the BOK-11

crew, had a Rezunov optical sight system, and the guns were slaved to follow the sightline to the target. Shavrov comments that this system was tested three years before a similar scheme was devised for the Boeing B-29.

The armament scheme was never fitted to the BOK-11 for reasons given in the description of that aircraft.

No data.

BOK-11

Purpose: Strategic reconnaissance.

Design Bureau: Bureau of Special Design, Smolensk. Chief designer Chizhevskii.

Having created aircraft with impressive range and high-altitude capability it was logical to go on and derive an aircraft able to fly with impunity for great distances over hostile territory carrying long-focus cameras. After argument it was decided to make this aircraft a three-seater, the third man being a gunner controlling the defensive system tested with the BOK-8. Design began in 1938. Two BOK-11

prototypes were ordered, and the first was flown in 1940. However, in 1938 Chizhevskii and several of his colleagues had been arrested (as was Filin soon after, see BOK-7), and this put the whole of BOK's operations under a cloud. As with many programmes at this time of terror, nobody wanted to do anything that might lead to any kind of failure. So, even though the first BOK-11 was delivered to the NII-WS (where its official walk-round photographs were taken on 4th November 1940), test flying was soon abandoned. There seems little doubt that reports of the 'BOK-15'

really refer to the BOK-11, in which case, for Nil testing, the No1 aircraft was assigned to A B Yumashev and the No2 to G F Baidukov.

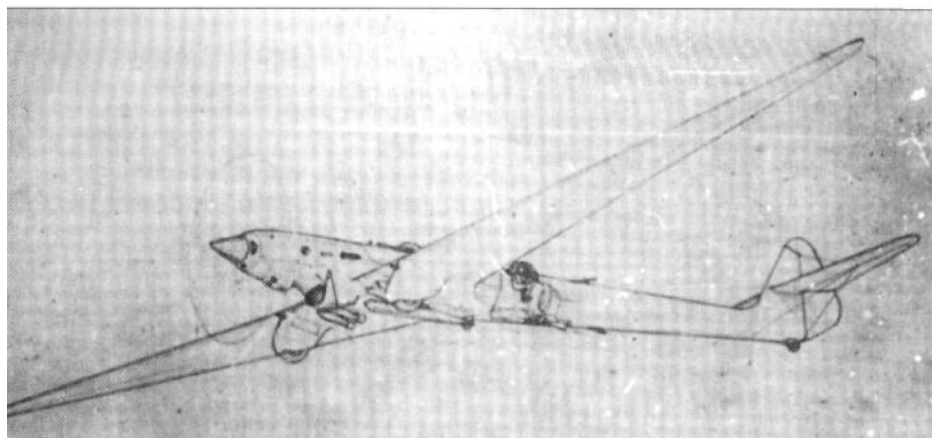
In general the BOK-11s were similar to the BOK-7, apart from having the massive 1,500hp Charomskii ACh-40 diesel engine to give increased range. The large radiator was in a duct under the leading edge. Each of the long-span ailerons had two mass-balances on its underside, the tailplane was wire-braced, and the elevators and tabbed rudder were fabric-covered. The armament system and gunner station were never installed.

There is no reason to doubt that a properly developed BOK-11 could have given the Soviet Union a strategic-reconnaissance capability considerably better than that of any other country. As noted under the BOK-7, the atmosphere of fear in 1940 led to this programme being abandoned.

| | | |
|------------|------------------|---------------------------------------|
| Dimensions | | |
| Span | 34.0m | 111ft6 ³ / ₄ in |
| Length | 12.9m | 42 ft 4 in |
| Wing area | 87m ² | 936.5ft ² |

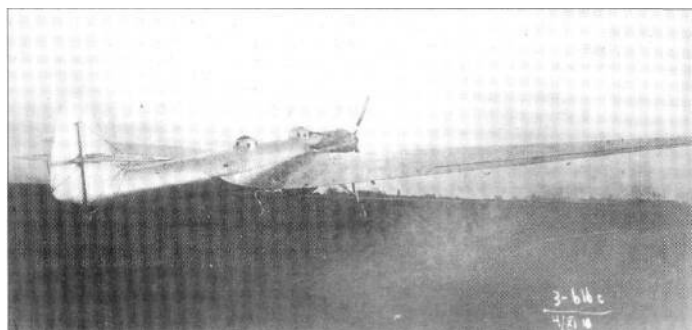
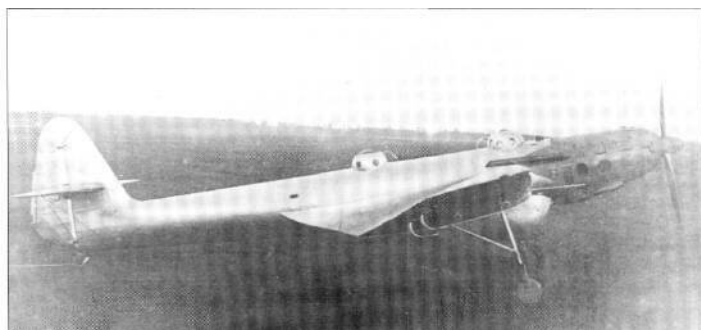
| | | |
|---------------|----------|-----------|
| Weights | | |
| Empty | 4,090 kg | 9,017 lb |
| Loaded | 10,000kg | 22,046 lb |
| Maximum speed | 252 knYh | 157 mph |

No other data.



OKB drawing showing that BOK-11 was originally intended as a bomber, with fixed landing gear.

Two views of BOK-11.



Bolkhovitinov S

Purpose: Ultra-fast attack bomber.

Design Bureau: WIA (air force engineering academy) located at the Zhukovskii Academy, Moscow, where Viktor Fedorovich Bolkhovitinov was Professor of Aircraft Design and head of design team.

The objective was to make the fastest bomber in the world, by using a fighter-type layout with two powerful engines in tandem. This arrangement was adopted in order to achieve engine-out safety with minimum drag. Design of the propulsion system began in 1936 and of the aircraft itself a year later. The designation stood for Sparka (Twin), but other designations were S 2M-103 (in usual Soviet style, showing the engines), BBS-1 (short-range bomber, fast, the S here meaning Skorostnii, speedy) and LB-S (light bomber, twin). Construction of the single prototype began in July 1938, the first flight was made by B N Kudrin in late 1939, and NII-WS testing took place between March and July 1940, the pilots being Kudrin and AIKa-banov. It was found that take-off run was excessive. In 1940-41 the aircraft was subjected to major modifications. ZI Itskovich redesigned the wing with increased area and a changed aerofoil profile. A different front en-

gine was fitted, and the rear engine and its propeller were replaced by an inert mass. The oil coolers were incorporated in the main radiator duct. As the redesigned aircraft neared completion snow was still on the ground, and the landing gears were all replaced by fixed skis.

No way was found to make proper use of the bay previously occupied by the rear engine, and in any case performance was now unimpressive. After the German invasion work was abandoned. Plans for an improved S bomber and a derived I (or I-1) fighter with two M-107 engines were also dropped.

The airframe was entirely a modern light-alloy stressed-skin structure. The wing was based on a structural box with two plate spars with flanged lightening holes, sheet ribs and heavy upper and lower skins with flush riveting. The fuselage basically comprised top, bottom and side panels all joined to four strong angle-section longerons (Shavrov: 'later this construction was used for the IL-28', a post-war jet bomber). The twin-finned tail had thin DI skin throughout, the rudders having inset balanced hinges, the tailplanes being pivoted and driven by irreversible trimming motors and the elevators having trim tabs and a variable geared drive. Each main

landing gear retracted electrically backwards, the wheel turning through 90°.

The 960hp M-103 engines (V-12 liquid-cooled derived from the Hispano-Suiza 12Y) were mounted in tandem, the rear engine driving the rear unit of the contra-rotating six-blade propeller. Some reports state that the drive was taken via left/right twin shafts past the front engine's crankcase, but in fact (as in the Italian Macchi M.C.72 racing seaplane of 1933) the rear engine drove a single shaft between the front-engine cylinder blocks which finally passed through the centre of the front-engine propeller shaft. Both engines were served by a large ducted radiator with a controllable exit flap (this was positioned by one of the 29 on-board electric actuators) and two oil coolers were fitted in ducts on each side of the front engine. Four fuel tanks were housed between the wing spars, and on the trailing edge were electrically driven slotted flaps (in several reports, incorrectly called Fowler type).

Pilot and navigator sat in tandem, far apart under a long Plexiglas canopy. The navigator also had a bomb sight, and the entire area around his seat was skinned in Plexiglas. Turning to the rear he could fire a 7.62mm ShKAS, and it was the intention later to re-

place this by twin 12.7mm UBT. Behind the rear spar, under the pilot's cockpit, was a bay housing 400kg (882 lb) of bombs, with two electrically driven doors. It was the intention later to fit fixed guns in the wings.

The second wing, of NACA-230 profile, gave improved field length. One report states that a remotely controlled ShKAS was added in the extreme tail, but this does not appear in any known photographs. Continued potentially dangerous problems with the rear engine and its drive resulted in this being removed. The front engine was changed to an M-105P, of unchanged 960hp, driving a single three-blade propeller. Even with weight considerably reduced the S was then judged a failure, though tandem-engine studies continued. The factory was tooled up for Pe-2 production.

Though an article by Ing V Mikhailov and Ing VPerov states that, following initial Nil testing 'the design team was instructed to continue development', there is no doubt the S was always on the verge of success but never getting there. The high wing loading and the failure to solve the rear-engine drive problem made it one of the programmes abandoned after the invasion of June 1941.

Dimensions

| | | |
|----------------------|---------------------|--------------------------------------|
| Span (original) | 11.38m | 37 ft 4 in |
| (new wing) | 12.2m | 40 ft X in |
| Length (original) | 13.2m | 43 ft 4 in |
| (one engine) | 13.0m | 42ft7 ³ / ₄ in |
| Wing area (original) | 22.9 m ² | 246.5ft ² |
| (new wing) | 23.43m ² | 252.2 ft ² |

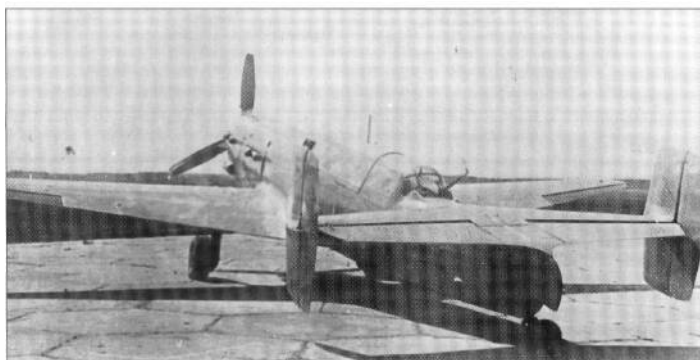
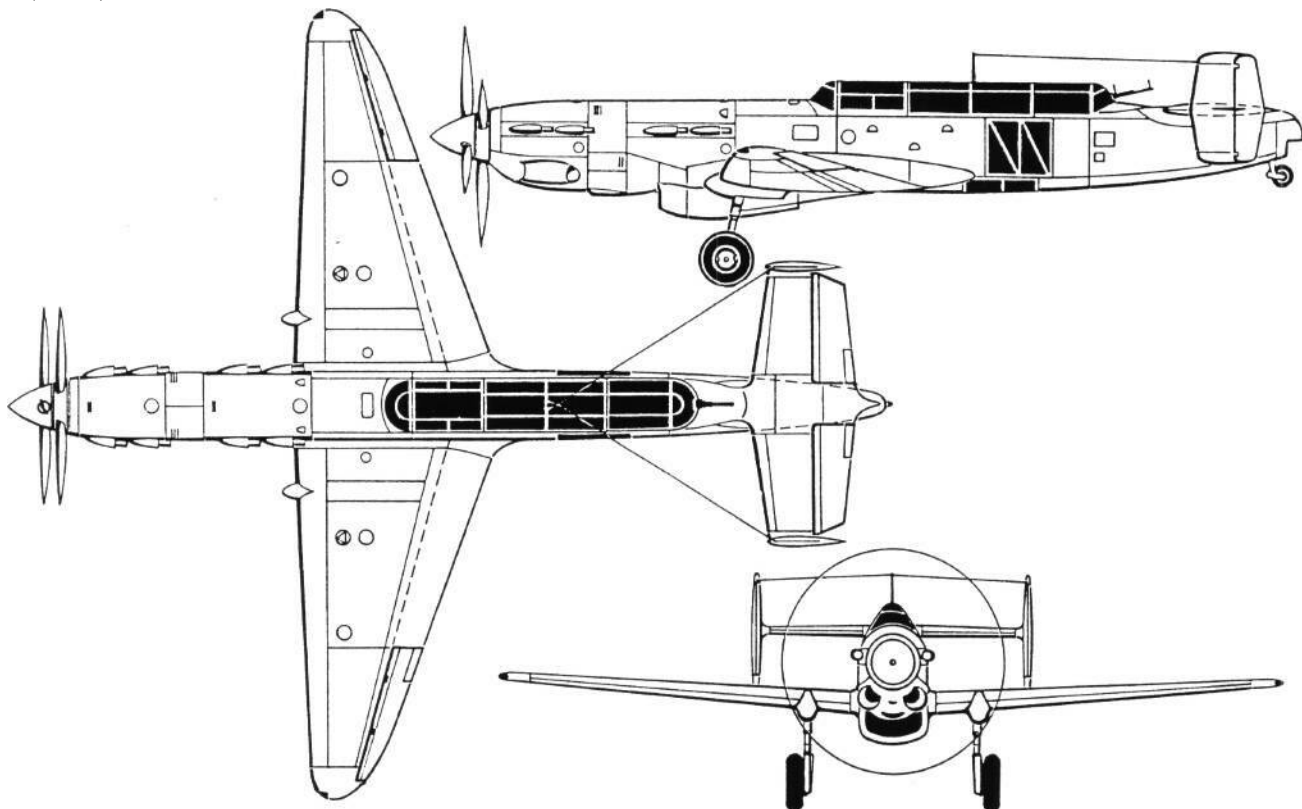
Weights

| | | |
|-------------------------------------|----------------|-----------|
| Empty | not discovered | |
| Loaded (original) | 5,652kg | 12,460 lb |
| (lightened, to reduce take-off run) | 5,150 kg | 11,354 to |
| (single engine) | 4,000kg | 8,818 lb |

Performance

| | | |
|---------------------------|----------|-----------|
| Maximum speed (original) | | |
| at 4,600m (15,092 ft) | 570km/h | 354 mph |
| (one M-105P) | | |
| at 4,400m (14,436ft) | 400 km/h | 248.5 mph |
| Range (two engines) about | 700km | 435 miles |
| Take-off run (original) | 1,045m | 3,428ft |
| (lightened) | 860m | 2,822ft |
| (one engine) | 700m | 2,297ft |
| Landing speed (original) | 180 km/h | 112 mph |
| (lightened) | 165 km/h | 102.5 mph |
| (one engine) | 135 km/h | 84 mph |

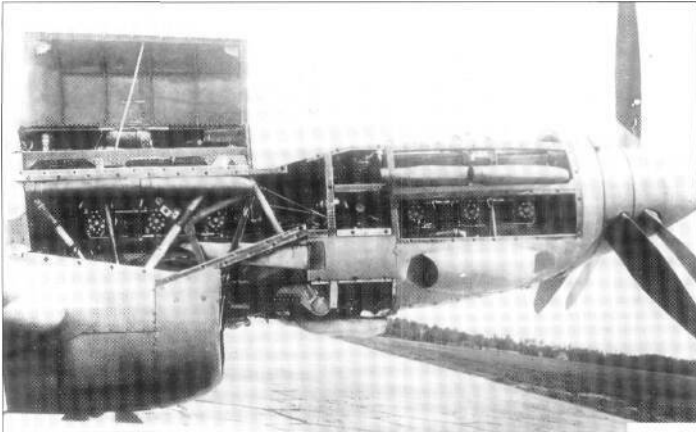
S (as built)



S (as built).



S (as built).



S (as built).



S (converted to single engine).

Chetverikov SPL

Purpose: Reconnaissance from submarines.

Design Bureau: Brigade of Ivan Vyacheslavovich Chetverikov in CAHI (TsAGI).

Later a famous designer of marine aircraft in his own right, Chetverikov was intrigued by the British submarine M-2, which carried a small aircraft for reconnaissance purposes. Though this proved a disaster in January 1932 when the M-2 was dived with the hangar door open, this did not invalidate the basic concept. Funds were obtained from both the MA (naval aviation) and the Glavsevmorput' (Chief Administration of Polar Aviation Northern Sea Route). Accordingly Chetverikov designed a small monoplane in two forms: the OSGA-101 amphibian for Glavsevmorput' for use from icebreakers and the SPL (Samolyot dlya Povodnikh Lodok, aeroplane for submarine boats), a slightly smaller non-amphibious

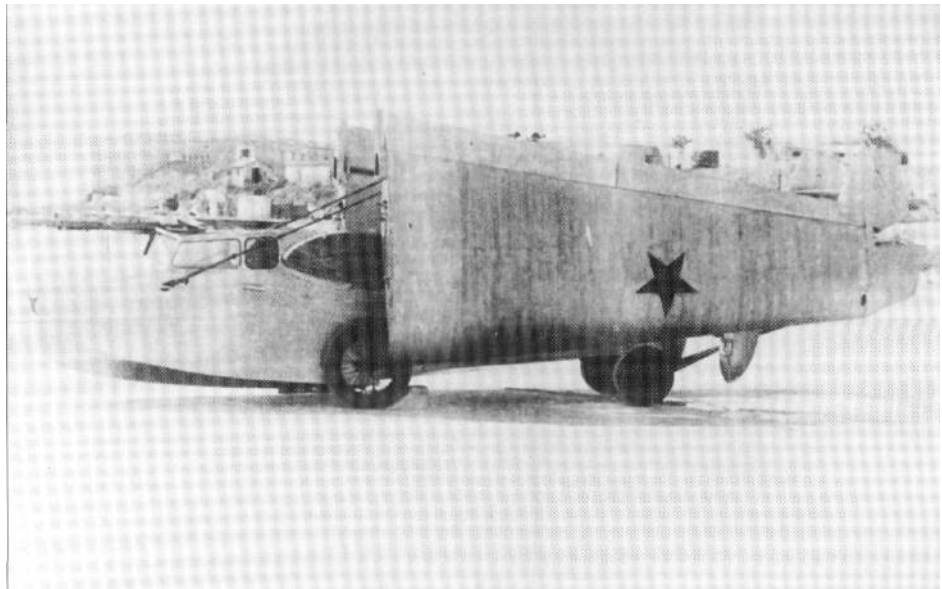
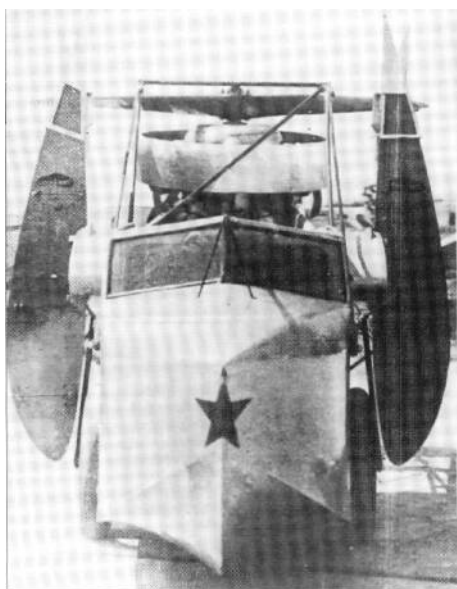
flying boat able to fold into a small hangar. OSGA flew in spring 1934. The SPL was completed in December 1934, taken by rail to Sevastopol and flown there by A V Krzhizhevskii in spring 1935. Testing was completed on 29th August 1935. Though the SPL was generally satisfactory, the idea of submarines with aircraft hangars was never adopted by the MA.

Like its predecessor, the SPL was a neat monoplane, of mainly wooden construction but with the tail made of D1 alloy covered with fabric and carried on booms of welded steel tube through which the control wires passed. The cockpit seated a pilot and observer side-by-side, and there was provision for a third seat or cargo immediately to the rear. The engine was a modest M-11 rated at 100hp, in a Townsend-ring cowl and driving a two-blade wooden propeller. The wings were fitted with plain flaps, and could be un-

locked and manually folded back with the upper surface facing outwards, the underwing floats also being hinged. The engine nacelle, on a steel-tube pylon, could likewise be pivoted straight back through 90°, so that after four minutes the whole aircraft could be pushed inside a watertight drum 7.45m (24ft 5Kin) long and 2.5m (8ft 21/2in) diameter (internal dimensions).

One report states that the MA claimed the SPL to have 'inadequate seaworthiness', while another states that it was difficult to take off from the open sea and was prone to stall because of poor longitudinal stability. The underlying factor was that the MA decided not to build large submarines with SPL hangars.

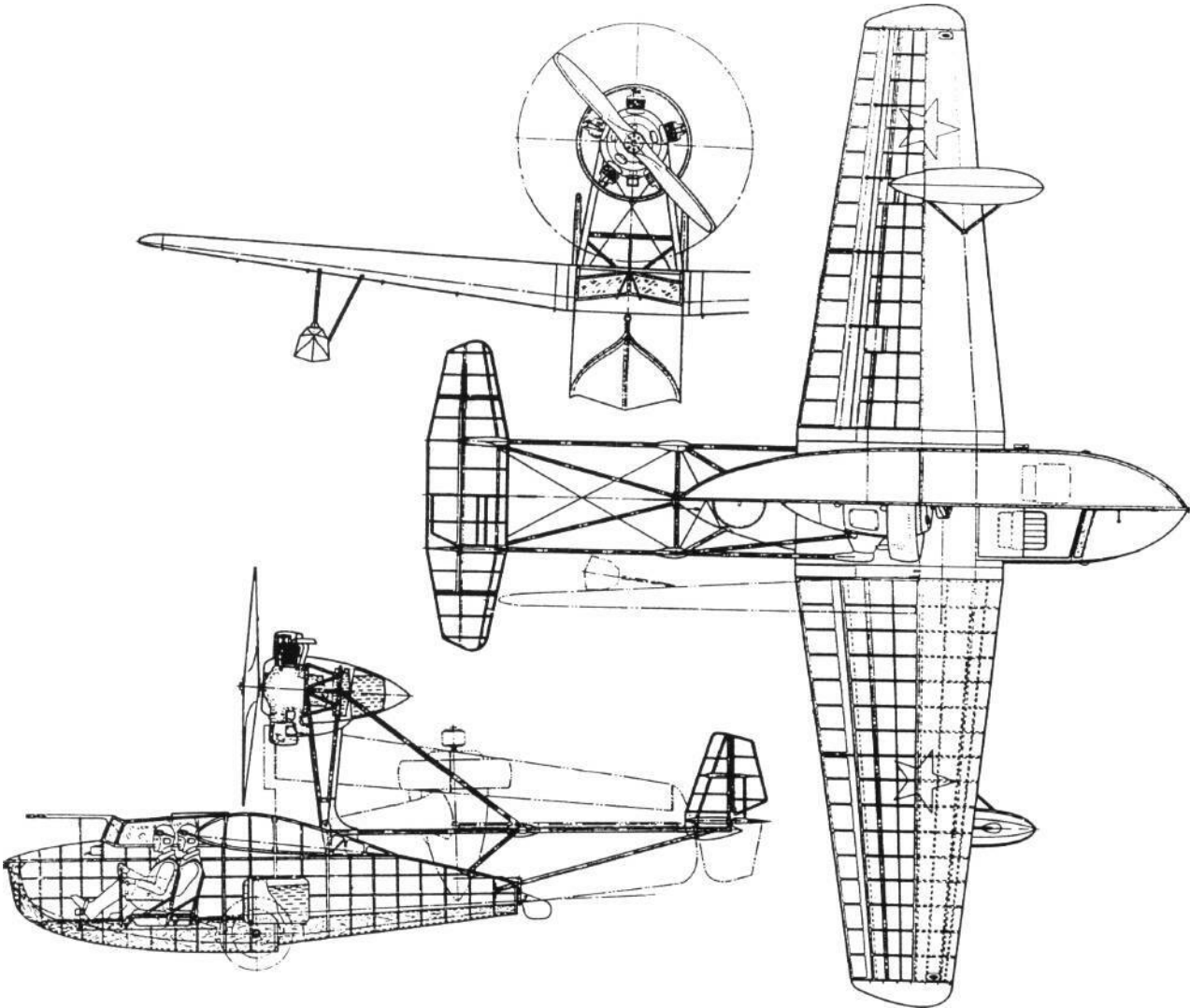
Two views of SPL folded.





| | | |
|--------------------------------------|--------------------|--------------------|
| Dimensions | | |
| Span | 9.5m | 31 ft 6 in |
| Length | 7.4m | 24 ft 3V. in |
| Wing area | 13.4m ² | 144ft ² |
| Weights | | |
| Empty | 592kg | 1,305lb |
| Fuel/oil | 60+ 10 kg | 132+221lb |
| Loaded | 800kg | 1,764lb |
| Maximum | 879kg | 1,938lb |
| Performance | | |
| Maximum speed | 186 km/h | 115.6 mph |
| Cruising speed at 2,500 m (8,200 ft) | 183 km/h | 114 mph |
| Time to climb to 1,000 m | 3.9 min | (3,280ft) |
| to 3,000 m | 15.3min | (9,843ft) |
| Service ceiling | 5,400m | 17,717ft |
| Range | 400km | 248 miles |
| Alightspeed | 85km/h | 53 mph |

SPL (the man is not Chetverikov) with ARK-3-2 in background.



Ejection-seat Test-beds

Purpose: To modify established jet aircraft in order to test ejection-seats.

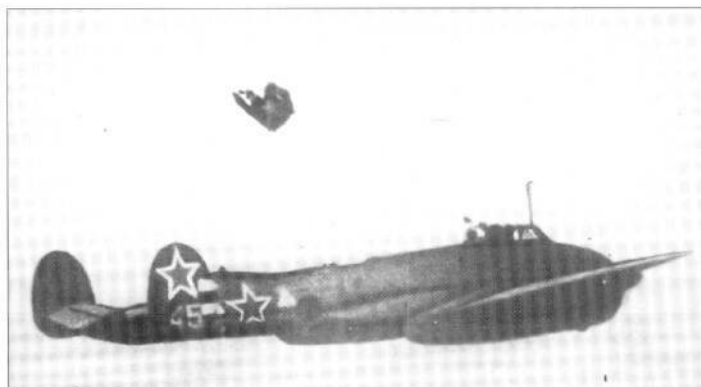
Design Bureau: Initially the seats were designed by special teams formed in the jet-aircraft OKBs. However, in 1952 a special organization was created to specialize in life-support and safety-equipment systems, and in 1994 this was transformed into NPP Zvezda (Star) joint-stock company. From the 1960s this organization captured the market until it was providing ejection-seats for virtually all Soviet combat aircraft.

Soviet ejection-seats, called Katapul'tnoye Kreslo, were initially diverse, and drew heavily on designs by US, Swedish and, especially, the British Martin-Baker companies. After 1945 a few flight tests took place with German seats, developed in 1944 for such aircraft as the He 219 and Do 335. The detailed history has not been written, but some of the earliest

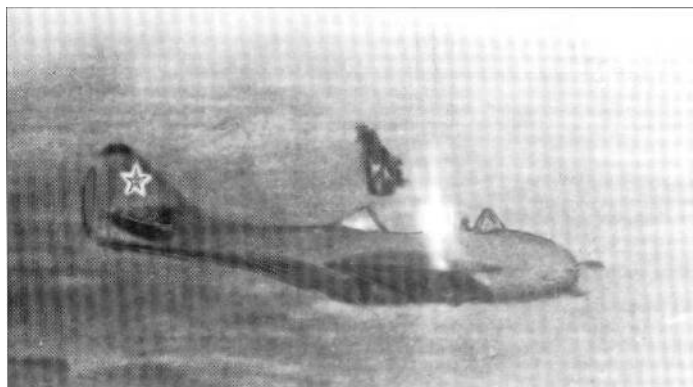
flight tests were carried out from about mid-1947. Probably the first Soviet ejection-seat was designed in the MiG OKB from January 1947. On 11th March 1947 this OKB received an order to test this seat in the FT-2, the second prototype of the MiG-9UTI trainer. After ten test ejections in a ground rig the experimental seat, weighing 128.5kg (283 lb), was initially installed in the considerably modified rear cockpit of FT-1 (the first two-seater which was still with the MiG OKB). Flight testing took place throughout the first half of 1948, but only up to 700km/h (435mph). The very similar FT-2 was then fitted with two ejection-seats, the front one at a rail angle of 22.5° and the rear at 18.5°. The modified aircraft was delivered to NII-WS, the air force flight test institute, on 29th September 1948. After two tests with dummies live testing continued between 7th October and 13th November 1948. An automatic sequence firing

the canopies and seats was then perfected (though of course the FT-2 was never left with both cockpits empty). From the results of these tests the OKB gradually developed the first production seat, called the SK. This was then developed through 14 production series.

Probably the next Soviet aircraft to be used for ejection-seat testing was the Ilyushin IL-28 tactical twin-jet bomber. First flown on 8th July 1948, using the imported Rolls-Royce Nene and later the Nene-derived RD-45 and VK-1A, this excellent aircraft was used for surprising tests using seats fired from the extreme tail. Unlike the very similar British Canberra, which was undefended, for this aircraft the Ilyushin OKB developed a powerful tail turret with two NR-23 guns, manned by the radio operator who had an escape chute. In several aircraft the turret was replaced by a special test installation for an ejection-seat. Both upward- and downward-firing seats



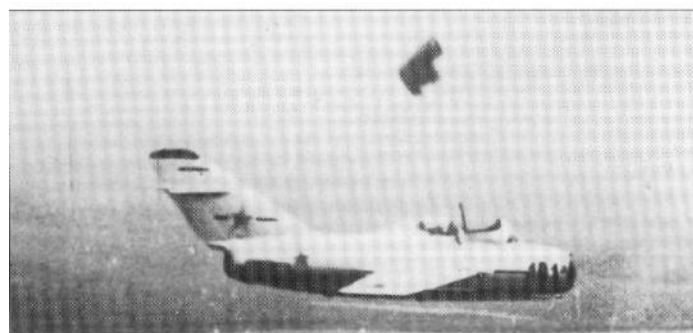
Pe-2 (German seat) test-bed.



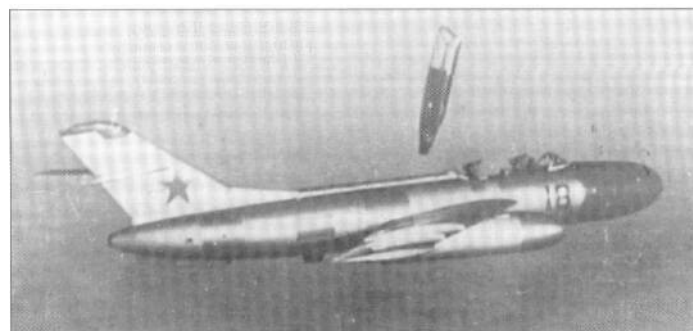
MiG-9 (FT-1) test-bed.



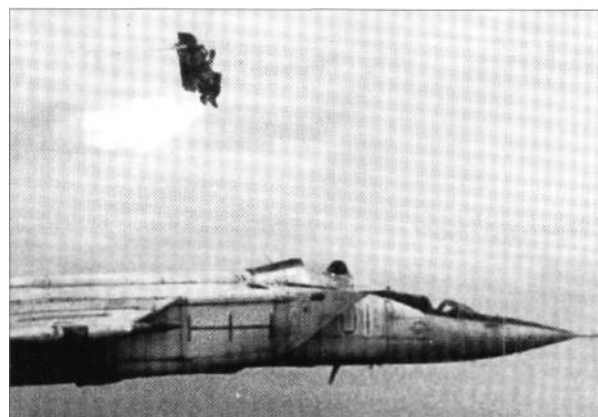
IL-28 (downward firing) test-bed.



UTI MiG-15 (ST-10) test-bed.



Right: Yak-25 (modified canopy).



were tested, and cine films showed that in some cases firing the seat imparted to the aircraft a pronounced kick in the pitching plane, either nose-up or nose-down. Some of the IL-28 seat tests were at airspeeds exceeding 800km/h (497mph).

Even higher speeds were reached during seat testing with ST-10 aircraft, which were specially modified two-seat UTI MiG-15s. This was the principal type used from 1951 onwards in development of the SK and SK-1 seats which were used in thousands of early MiG jets, and later for the much better KM-1 family used in later MiG fighters, cine films and photographs have shown seats being fired from ST-10s with callsigns 15, 23, 101U, 102U and 401U. These aircraft were painted with bold horizontal black lines in known positions to assist determination of the seat trajectory. What is surprising is that about half the photographs of tests appear to have involved firing the test seat from the front cockpit. Using dummies and human occupants many hundreds of combinations of canopy, seat, ejection gun, stabilizing drogue and parachute system were investigated. Early SK seats were notoriously unreliable, and when they did fire on command the pilot often suffered spinal damage. Gradually, and especially after the ST-10 testing began, the SK seats improved. A faceblind was provided to

protect the occupant's face, additional firing triggers were incorporated in both armrests, improved ejection guns were developed imparting a precisely repeatable phased acceleration using different cartridges for summer and winter, and the original restrictive limits of airspeed and altitude were progressively increased. A photograph shows 101U, one of the aircraft with a completely open front cockpit. The final ST-10, 401U, was fitted with a new type of front-cockpit canopy which was hinged at the rear to the top of the seat so that on ejection the canopy served as a wind-break to protect the occupant. This became a feature of early MiG-21 fighters.

Photographs have been found of at least two Yak-25L (Laboratoriya) seat-test aircraft. The production night fighter seated the pilot and radar operator in tandem under a large one-piece canopy which opened by sliding on rails 2.2m (7ft 5in) to the rear. Both the seat test-beds had a pressure bulkhead separating the front cockpit from the rear cockpit, from which the seat under test was fired. Aircraft callsign 18 retained the original type of canopy but with the portion over the rear cockpit opaque (on being jettisoned this usually passed perilously close to the tail). Aircraft callsign 01 had a completely modified arrangement, the pilot having a short upward-hinged canopy and the test cockpit having a

Top: Sukhoi Su-9U test-bed.

Above left: Yak-25L zero-altitude ejection-seat test.

Above right: Test ejection from MiG-25U.

prominent light-alloy superstructure which in most tests was open at the top. This aircraft was later used to test the Yakovlev OKB's KYa-1 rocket-boosted seat, the first to have 'zero/zero' capability (able to be fired with the aircraft at rest on the ground).

The only Sukhoi aircraft known to have been an ejection-seat test-bed was an Su-9U with callsign Red 10. Liberally covered on the starboard side with black lines for use as trajectory references, this Mach-2 aircraft always fired the test seat from the rear cockpit. This was open-topped and sealed from the pressurized front cockpit. The only photographs released on this aircraft must have been taken since the 1970s, as they show modern Zvezda zero/zero rocket assisted seats, at least one being of the K-36 family. One photograph shows a test at ground level.

While the Su-(U) was used for tests at high subsonic Mach numbers, at least on MiG-25U has been used to confirm behaviour in ejections at supersonic speeds. Details of the seats and Mach numbers have yet to be disclosed, but Zvezda believe this aircraft has been used to check successful ejections at mach numbers significantly higher than anywhere else in the world.

Experimental landing gears

Purpose: To use aircraft to test experimental landing gears.

Design Bureau: Various.

No country has as much real estate as the former Soviet Union, and the land surface is at times soft mud, sand, snow and hard frozen. Several designers concentrated on devising landing gears that would enable aircraft to operate from almost any surface. One of the first was N A Chechubalin, who in the 1930s was working at BRIZe, a division of Glavsevmorput', the chief administration of northern (Arctic) sea routes. He devised neat tracked main gears to spread the load and enable aircraft to operate from extraordinarily soft surfaces. His experimental gears were tested on a U-2 and a much heavier Polikarpov R-5.

In 1943 SAMostovoi picked up where Chechubalin had left off and designed caterpillar main landing gears for an Li-2 transport (the Soviet derivative of the DC-3). These gears were retractable, and made little difference to the performance of the aircraft, but they were 'unreliable in operation' and were therefore not put into production. Photographs have not yet been found.

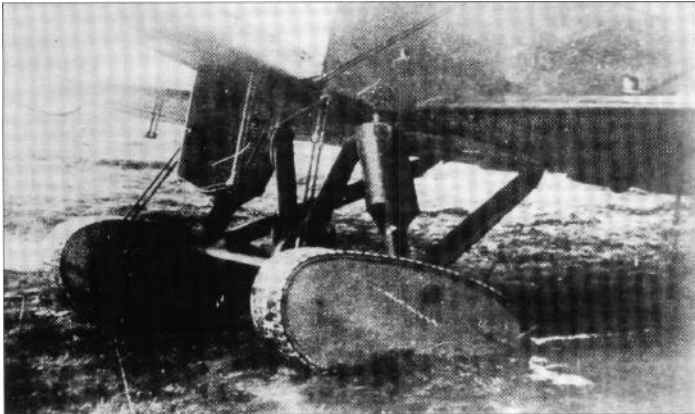
In 1937 Nikolai Ivanovich Yefremov collaborated with Aleksandr Davidovich Nadiradze

to design a unique inflatable gear which offered a totally different way of reducing footprint pressure in order to operate from almost any surface. Their answer was an 'air pillow' inflated under a semi-rigid upper sheet attached under the aircraft centreline. The scheme was called SEN, from the Russian for 'Aircraft Yefremov/Nadiradze'. The pillow was tested on a Yakovlev AIR-20 (UT-2), which was fitted with a 20hp motorcycle engine driving a compressor to keep the bag inflated. The only known photo does not show the wingtips clearly, so it is not known if wingtip skids were needed to stop the aircraft rolling over. In 1940 the SEN was test-flown by such famous pilots as Gromov, Shelest and Yumashev, but it never went into general use.

In 1991 the new private company Aeroric, at Nizhny Novgorod (in Communist days called Gorkii), began the design of a multirole transport called Dingo. Powered by a 1,100-shp Pratt & Whitney Canada PT6A-65B turbo-prop, driving a Hartzell five-blade pusher propeller, the Dingo is made mainly of light alloy and accommodates one or two pilots and up to eight passengers or up to 850kg (1,874lb) of cargo. Its most unusual feature is that it has no conventional landing gear. Instead it has a 250hp Kaluga TBA-200 (in effect

a turbofan) which generates an air cushion underneath, contained by inflated air bladders along each side and hinged flaps at front and rear. At full load the ground pressure is a mere 0.035kg/cm² (71.71lb/ft²), enabling the Dingo to ride over water, snow or any other surface and to cross ditches, ledges and projections up to 30cm (1ft) high. Cruising speed is 275km/h (170mph).

Though a surface skimmer rather than an aeroplane, the Stela M.52 seen at the 1995 Zhukovskii airshow was interesting for riding on an air cushion. This is contained by side skegs (underfins), a large rear flap and front hinged curtains.



Chechubalin landing gear on R-5 No 403.



Aeroric Dingo.



Stela M.52.



SEN (Yefremov) landing gear on UT-2.

Florov 4302

Purpose: Rocket-propelled aircraft for aerodynamic research.

Design Bureau: Ilya Florentyevich Florov (1908-83) had a long career at several OKBs and State organizations, some of his products being biplane fighters designed with A A Borovkov. In 1943 he headed a design cell in NII-WS (air force state test institute).

In 1943 Florov was assigned the task of creating a small rocket-engined aircraft to test wing profiles, flight-control systems and other features. At this time published German papers on swept wings (1935) had not been studied. Three examples of No 4302 were funded, and Nil pilots A F Pakhomov and I F Yakubov were assigned to the programme. The No 1 aircraft was not fitted with an engine, and made 46 flights from late 1946, on each occasion being towed to about 5,000m (16,400ft) by a Tu-2. The No 2 was flown under power, the first take-off (by Pakhomov) being in August 1947. In the same month the programme was terminated, funds being transferred to the MiG I-270. At this time the No 3 aircraft had for some time been complete but waiting for its RD-2M-3 engine.

The 4302 was a small aircraft with a fuselage dictated by the size of cockpit and pro-

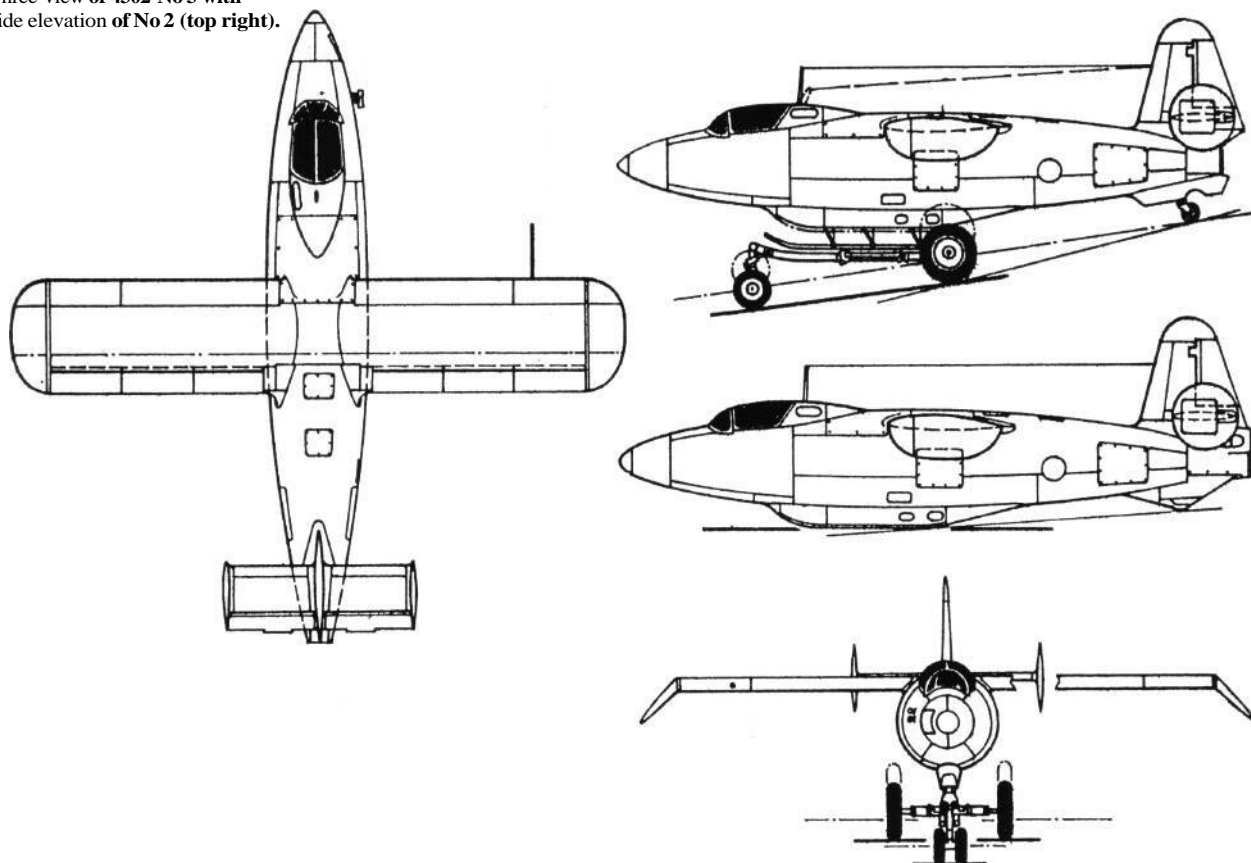
pellant tanks. Construction was entirely light-alloy stressed skin, with a very good surface finish. The untapered wings had a 13-per-cent laminar CAHI (TsAGI) profile devised by G P Svishchev. They were made as one unit attached above the fuselage, with down-turned tips. On each trailing edge were three sections of slotted flap which were also operated in opposition for lateral control. The tail comprised a fixed fin and tailplane, with fixed endplate fins, and manually driven rudder and elevators with inset hinges and mass balances. The pilot had a small pressurized cockpit in the nose with an upward-hinged canopy. The No 1 aircraft was completed with conventional fixed landing gear (using some La-5FN parts), for slow-speed glider flights. The Nos 2 and 3 were designed to take off from a tricycle-gear trolley and land on a centreline skid and tailwheel. The No 2 was fitted with a liquid rocket by A M Isayev assisted by L S Dushkin rated at 1,100kg (2,425 lb) at sea level. In the rear fuselage was a large tank for red fuming nitric acid made of 3mm Enerzh 18-8 stainless, wrapped with OVS wire to withstand gas feed pressure. Behind was the tank of petrol (gasoline). Later, in 1947 a more powerful 1,140kg (2,513 lb) Dushkin engine was fitted. The No 3 aircraft was to have been

fitted with an RD-2M-3 engine developed by Dushkin and V P Glushko, with main and cruise chambers with sea-level ratings of 1,450 and 400kg (3,197 and 882 lb). In this condition it was to have been designated No 4303. One report says that an RD-2M or RD-2M-3 was retrofitted to No 2, but there is no record of it flying with this engine.

These aircraft appear to have left no record of aerodynamic achievement.

| Dimensions | | |
|----------------------------|---------------------|-----------------------|
| Span (all) | 6.932m | 22 ft 9 in |
| Length (No 2) | 7.124m | 23 ft 5 in |
| (No 3) | 7.152m | 23 ft 5 in |
| Wing area (all) | 8.85 m ² | 95.26 ft ² |
| Weights | | |
| Empty (No 1) | 970kg | 2,138 lb |
| Loaded (No 1) | 1,350kg | 2,976 lb |
| (No 3) | 1,750kg | 3,859 lb |
| Performance | | |
| Max speed (No 2, achieved) | 826km/h | 513 mph |
| Landing speed (all) | 125km/h | 78 mph |

Three-view of 4302 No 3 with side elevation of No 2 (top right).





Above left: 4302 Nol.

Above right: 4302 No 2 in take-off configuration.



Left: 4302 No 2 after landing.

Grigorovich I-Z

Purpose: To evaluate a fighter with APK recoilless cannon.

Design Bureau: Team led by Dmitrii Pavlovich Grigorovich, in VT (internal prison) run by OGPU (secret police, later NKVD) at Factory No 39.

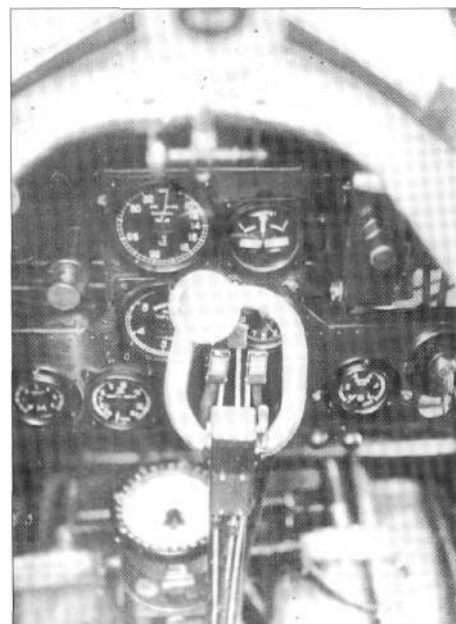
The story of the development in the Soviet Union of large-calibre recoilless guns, under the leadership of L V Kurchevskii, is outlined in the entry on the Tupolev ANT-23. By the end of the 1920s design bureaux were receiving contracts for experimental fighters designed to be armed with such weapons. In late 1929 Grigorovich was sent to Central Construction Bureau 7, which was really Hangar 7 at Factory 39, an OGPU secure prison for designers. Here he led the design of the Z, a secret monoplane to be armed with two 76.2mm (Sin) APK-4 guns. To speed construction the powerplant group and forward fuselage of the first prototype were the same as those of the Polikarpov I-5, which was also built in Hangar 7. The complete aircraft, called I-Z (Fighter Z) was flown by Benedikt Bukhgo'l'ts in (it is believed) early May 1931. It was inspected by Stalin, Voroshilov, Molotov and others on 6th July 1931. Subsequently a small series of 21 production I-Z fighters were produced at GAZ No 39. These were still regarded as experimental. In February/March 1933 aircraft No 39009 was placed on a high

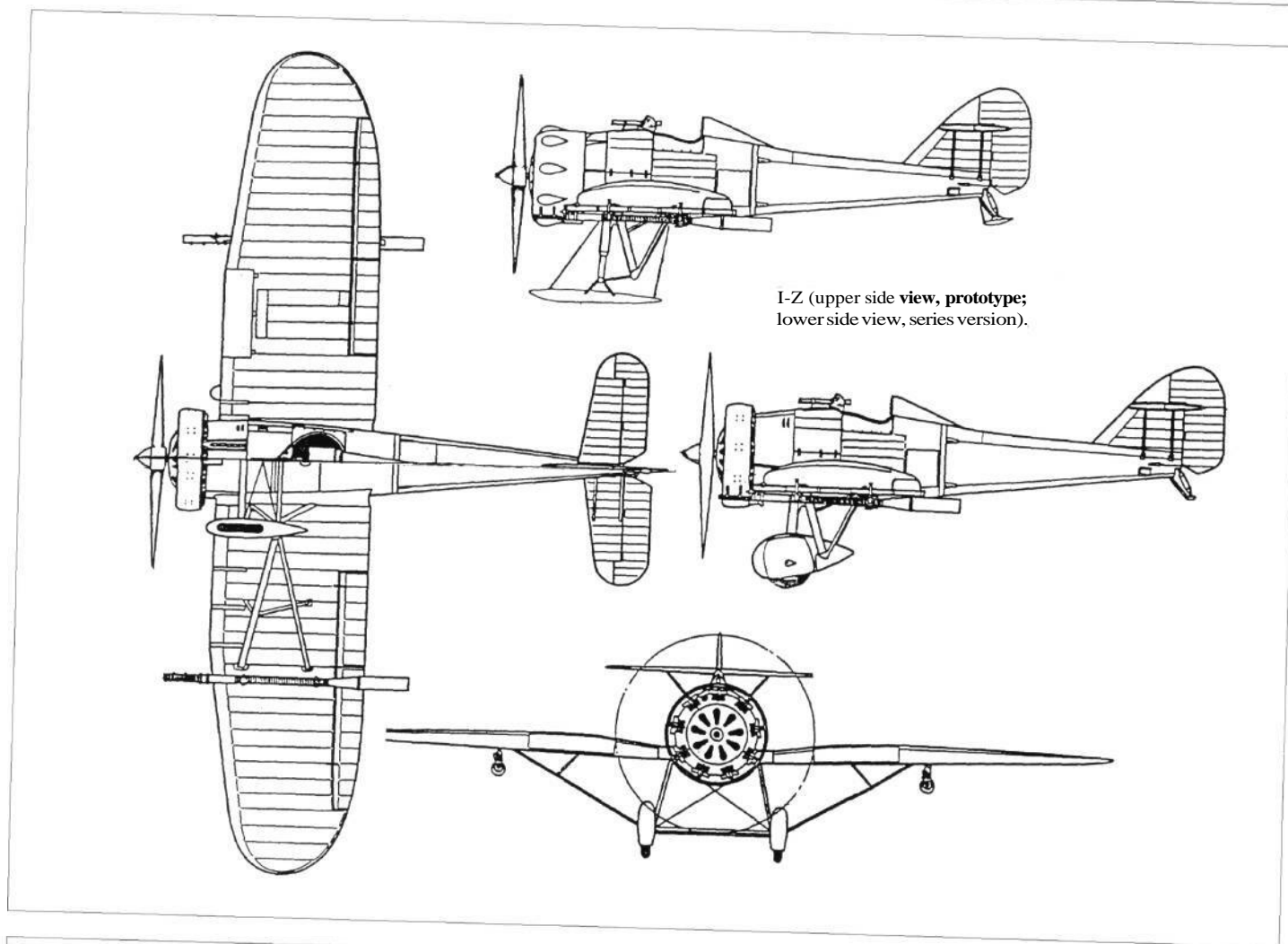
platform and used for firing trials, and in September 1933 No 39010 underwent NII-WS testing. Two of these aircraft were later used in Zveno trials, as described under Vakhmistrov. In 1934-35 Factory No 135 at Kharkov built a further 72, with modifications, designated IP-1. These saw only limited use, partly because of difficult spin recovery, but were not considered as experimental.

At this time monoplanes were still structurally difficult, and the wing, though of torch-welded stainless (Enerzh-6) lattice construction, still needed underwing bracing to the fixed landing gears. Apart from the semi-monocoque rear fuselage, the covering of the whole airframe was fabric. The prototype had a Bristol Jupiter, in a helmeted cowl, while the first production batch had the same 480hp engine built under licence as the M-22 and cowed in a Townend ring. The second batch, from Kharkov, had the 700hp M-25 (Wright Cyclone). The main landing gears variously had spatted wheels, plain wheels or skis. The guns were suspended from both main spars outboard of the struts (just inboard on the first prototype), and were fed at a slow rate from a seven-round magazine in the wing. A PV-1 machine gun was fitted to right of centre ahead of the windscreen to assist aiming using the optical sight. The tailplane was mounted high to avoid the rear blast from the APK-4s.

This neat aircraft did all that was expected of it, but none of Kurchevskii's big guns ever became operational.

I-Z cockpit.





I-Z (upper side view, prototype;
lower side view, series version).



Far left: I-Z series aircraft.



Left: Close-up of APK-4.

Bottom left: Aircraft I-Z No 39009 rigged for firing trials.



Dimensions (first I-Z)

| | | |
|-----------|--------------------|---------------------|
| Span | 11.5m | 37 ft 8% in |
| Length | 7.645m | 25 ft 1 in |
| Wing area | 19.6m ² | 211 ft ² |

Weights

| | | |
|--------|---------|----------|
| Empty | 1,180kg | 2,601 lb |
| Loaded | 1,648kg | 3,633 lb |

Performance

| | | |
|------------------------|-----------------|-----------------|
| Max speed at sea level | 259km/h | 161 mph |
| Time to climb to 5 km | 14min | (16,400ft) |
| Service ceiling | 7km | 22,970ft |
| Range | 600km | 373 miles |
| Take-off run | 110m | 361ft |
| Landing speed/ run | 100km/h 180m | 62 mph 591ft |

Grokhovskii G-31, Yakob Alksnis, Strekoza

Purpose: To build a troop-carrying glider; this was later modified into powered aircraft.

Design Bureau: WS-RKKA (Red Army special design team for aviation forces), director Pavel Ignatyevich Grokhovskii (1899-1946).

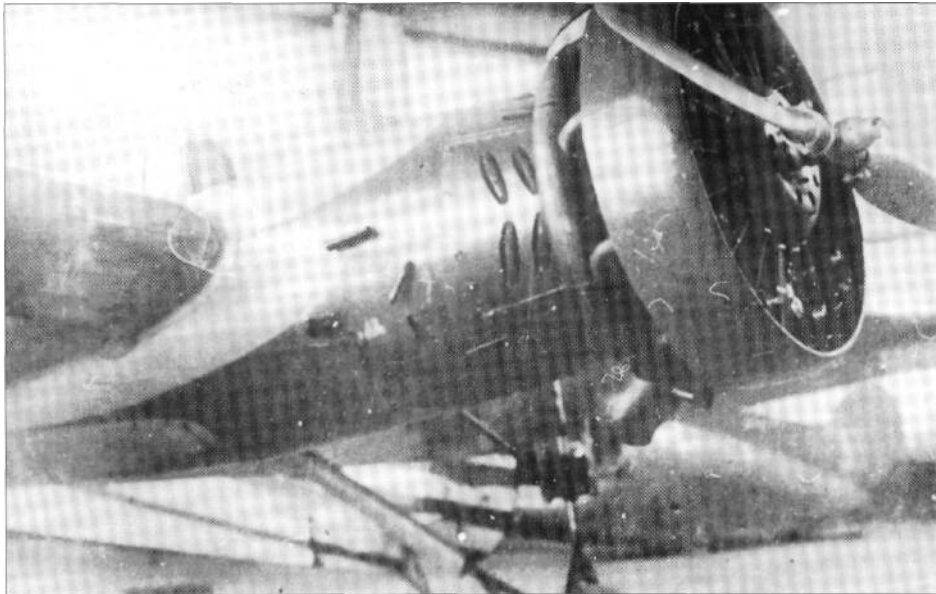
Grokhovskii had a brief but intense career, forming a branch of WS-RKKA in Leningrad in 1934 and seeing it liquidated in 1936. Most of his designs were concerned with assault by airborne forces, and all showed a remarkable originality. The G-61 was a 'people pod' able to house seven armed troops and actually flown attached under each wing of an R-5, a mass-produced 700hp biplane. The G-31 (in some documents called G-63i>/s), named for WS Gen Yakob Alksnis, was a giant cargo glider, designed by Grokhovskii and B D Urlapov to carry troops lying inside the wing. From this Grokhovskii produced the G-31 powered aircraft. First flown in late 1935, it flew to Moscow in 1936 for RKKA testing. It was eventually decided that the

arrangement of troops packed inside the wing, with no chance of escape in flight, was unacceptable. In any case, the concept of a powered glider for assault operations was eventually considered unsound.

Sharing a strengthened version of almost the same airframe as the glider, the G-31 (again named for Alksnis and also dubbed Strekoza, dragonfly) was a graceful aircraft as befits a powered version of a glider. Though intended for military purposes it was one of several types designed in the 1930s with no consideration of speed, because this was not thought significant. The airframe was wooden, with a vestigial fuselage of multiply veneer formed by presses with double curvature. On the front was a puny 100hp M-11 five-cylinder radial. Subsequently Grokhovskii built a G-31 with a strengthened structure matched to the 700hp M-25, an imported (later licensed) Wright R-1820 Cyclone. This was fitted in a Townend-ring cowl and it drove a Hamilton light-alloy ground-adjustable propeller. It is believed that later a three-blade flight-variable Hamilton Standard

was fitted. As in the glider there were cockpits for a pilot and flight engineer, while between the wing ribs were compartments for 18 troops, nine in each wing (drawings show eight in each wing). They boarded and were extracted through hinged leading edges, which were transparent, as in the G-61 pods.

Few details of the G-31 have survived. Clearly the naming of this aircraft and its predecessor after Alksnis was a mistake, because he was arrested in 1936 and executed in 1938. The close-knit Grokhovskii team was 'liquidated' very soon after the General's arrest.



Dimensions (M-25 engine)

| | | |
|-----------|--------------------|--|
| Span | 28.0m | 91 ft M in |
| Length | 13.9m | 45 ft 7 ¹ / ₂ in |
| Wing area | 70.5m ² | 759 ft ² |

Weights

| | | |
|--------|---------|----------|
| Empty | 1,400kg | 3,086 lb |
| Loaded | 3,200kg | 7,055 lb |

Performance

| | | |
|---------------------------------------|---------|--------|
| Maximum and cruising speed limited to | 135km/h | 84 mph |
|---------------------------------------|---------|--------|

No other data.

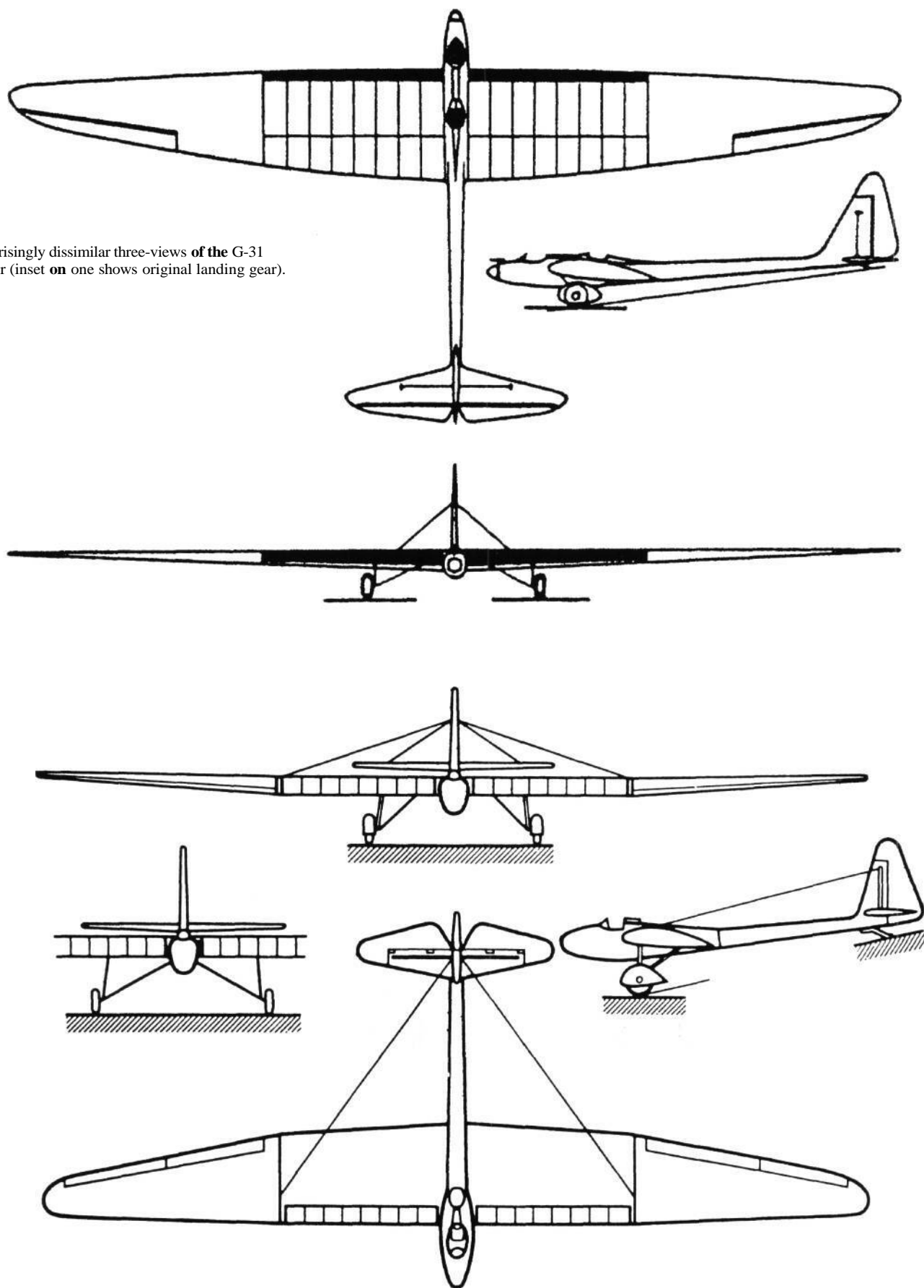
Left: G-31 with M-25 engine.

Below left: G-31 glider.

Below right: G-31 with M-11 engine.



Surprisingly dissimilar three-views of the G-31 glider (inset **on** one shows original landing gear).



Grokhovskii G-37, ULK

Purpose: 'Universal flying wing'.
Design Bureau: WS-RKKA Leningrad, Chief Designer Vladimir Rentel.

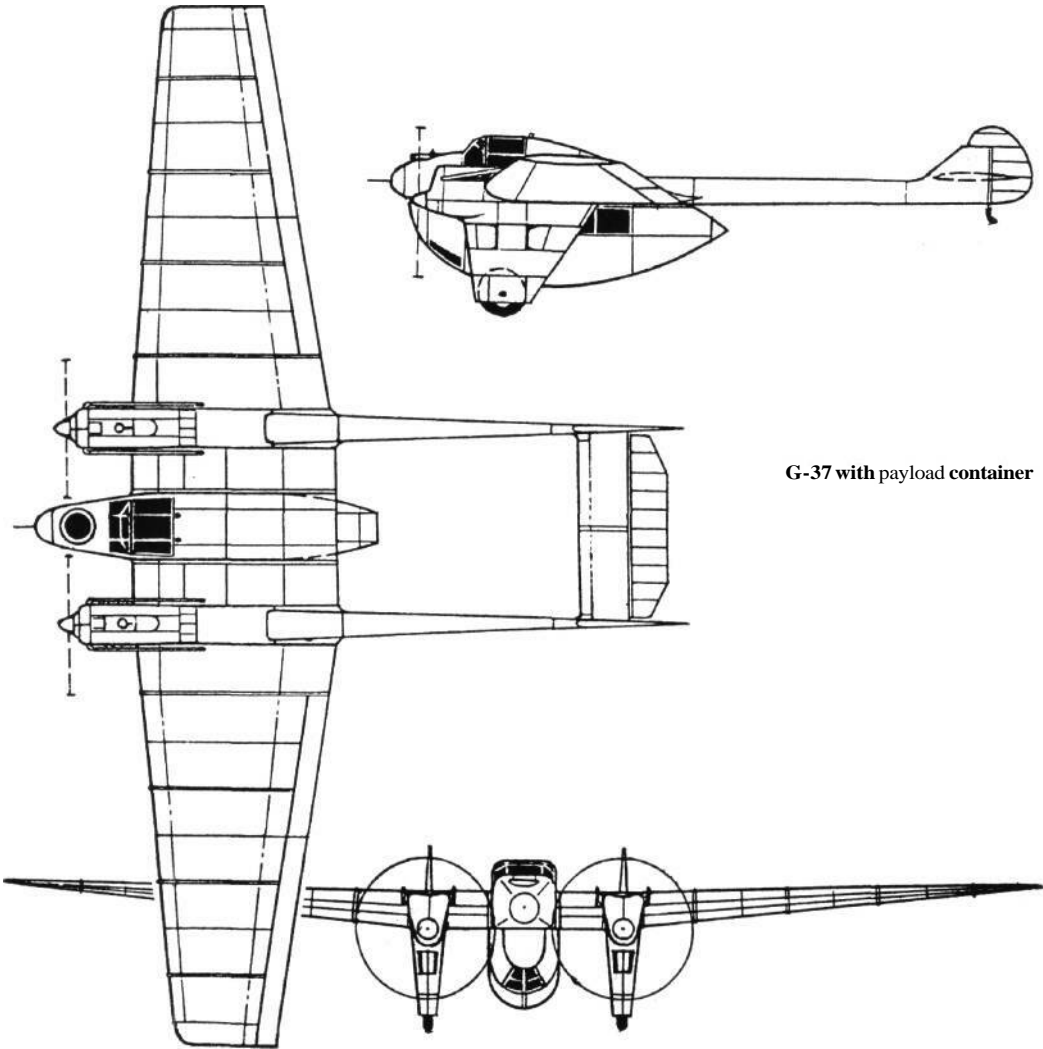
The numbering of 'Grokhovskii' aircraft is difficult to interpret, and this aircraft preceded the G-31. The concept was that of a versatile aircraft for airborne assault, but it was soon evident that a Universalnoye Letayushcheye Krylo, universal flying wing, would have wide commercial appeal. Construction was assigned to Vladimir Rentel, who had the aircraft built in Grebno (rowing) port, Leningrad. It was taken to the airfield where from November 1935 it was tested by VPChkalov, who was impressed. He later flew it to Moscow in 2hrs 50min (average 250km/h, 155mph, which Shavrov says was 'almost a record'). The G-37 was used for a long series of tests, including dropping of heavy loads.

The G-37 was a remarkably capable early example of an aeroplane designed to lift a detachable payload container (later types in-

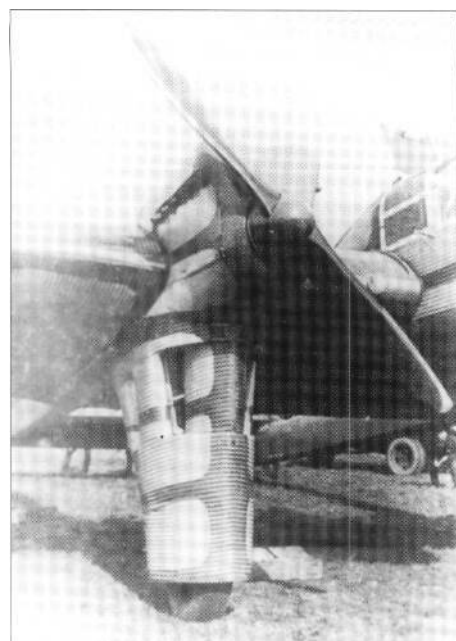
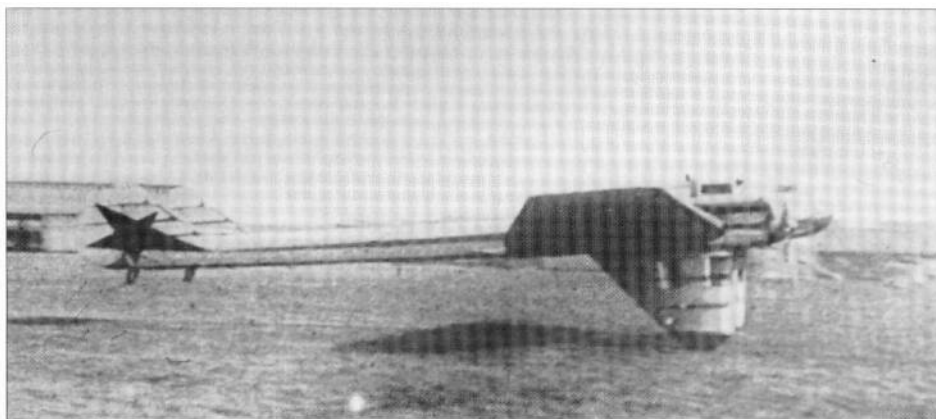
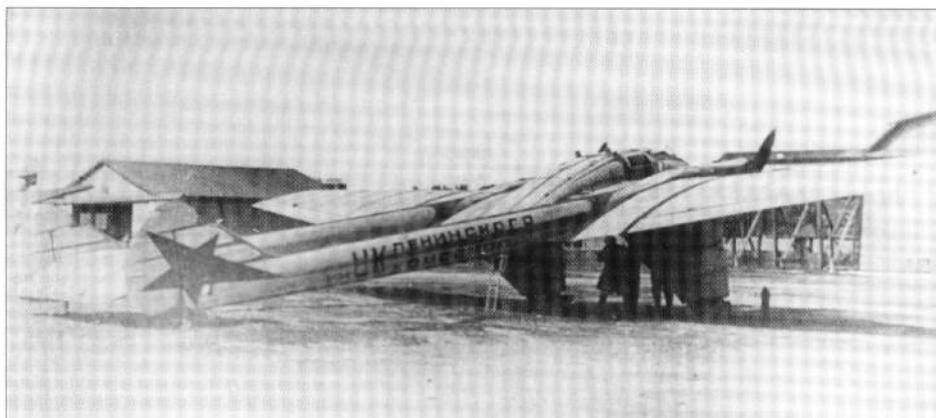
cluded the Fi333, Miles M.68 and Fairchild XC-120). To save time the wing was that of an ANT-9 (PS-9), made of Kolchug duralumin with mainly corrugated dural skin, though the ailerons did not project beyond the wing tips. It is possible this wing came from a crashed PS-9 along with the 680hp BMW VI water-cooled V-12 engines, though these were in a different installation. The engine cowlers were extended down into large trousers over the main landing gears, which contained the engine-cooling radiators. At the rear they extended into tail booms, all these structures being of light alloy. Each boom had a tailwheel, and the twin-finned tail was duralumin with fabric covering. On the centreline the wing was expanded into a small nacelle for the pilot and engineer. The underside of the centre wing was provided with attachments for a standard pre-loaded payload container, though no photographs have been found with this in place. The completed G-37 was painted with gay stripes and stylized red stars and slogans.

There seems little doubt that this was an excellent and potentially versatile aircraft, and it is not known why it was never ordered for military or civil use.

| | | |
|---|--------------------|--|
| Dimensions | | |
| Span | 22.5m | 73ft9 ³ / ₄ in |
| (possibly for a developed version, Shavrov cites) | | |
| | 23.7m | 77 ft 9/4 in |
| Length | 13.85m | 45 ft 5 ¹ / ₂ in |
| (Shavrov) | 16.0m | 52 ft 6 in |
| Wing area | 84.0m ² | 904 ft ² |
| Weights | | |
| Empty | 3,100kg | 6,834 lb |
| Loaded | 5,700kg | 12,566 lb |
| Performance | | |
| Max speed at sea level | 235km/h | 146 mph |
| at 2,500m (8,200ft) | 285 km/h | 177 mph |
| Cruising speed at | | |
| 2,500m (8,200 ft) | 250 km/h | 155 mph |
| Time to climb to 6 km | 16min | (19,685ft) |
| Service ceiling | 6,500 m | 21,325ft |
| Landing speed | 90 km/h | 56 mph |

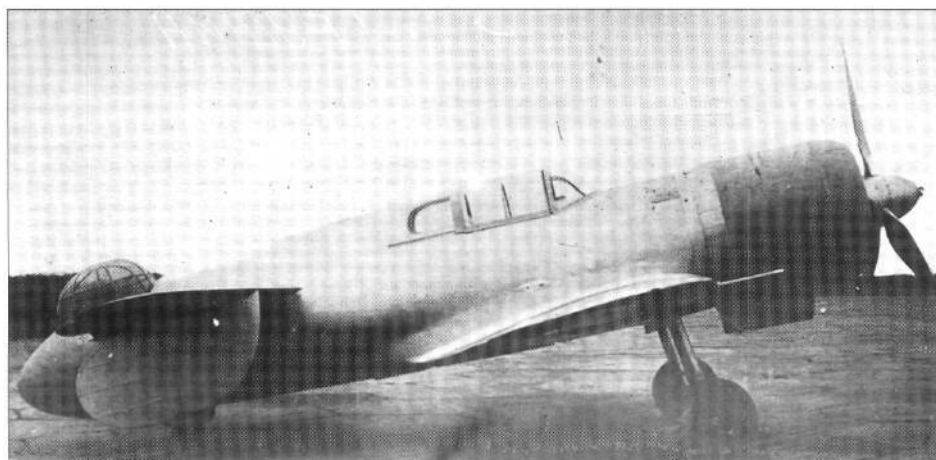


G-37 with payload container



Three views of G-37 without payload container.

Grushin Sh-Tandem, MAI-3



Purpose: To devise an improved configuration for a tactical attack aircraft.

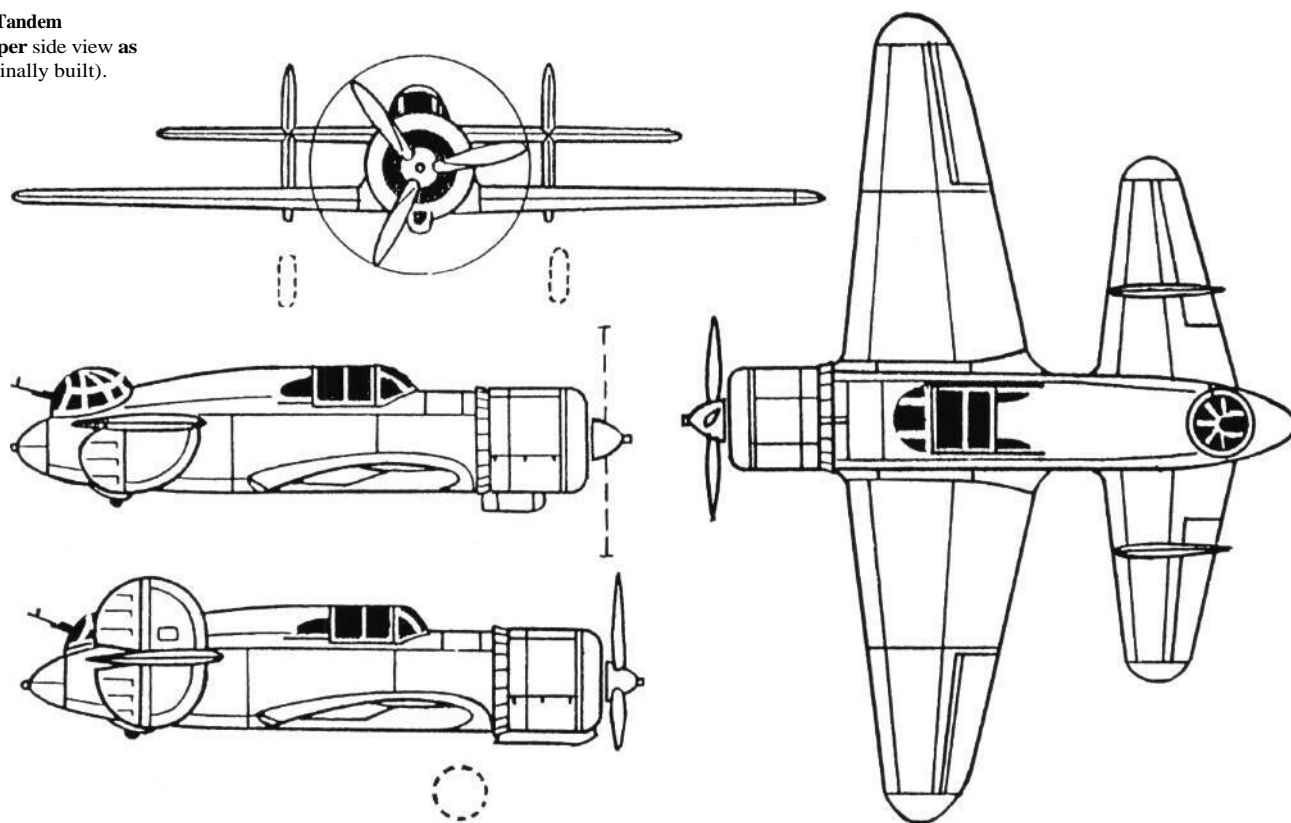
Design Bureau: Moscow Aviation Institute, designer Pyotr Grushin.

Born in 1906, Grushin worked on various aircraft at MAI, as well as a remarkable steam engine tested in a U-2 (Po-2). In 1935 he began scheming a tandem-wing aircraft, thinking this could form the basis of an attack aircraft with a rear gun turret. The single example of the Sh-Tandem (Shturmovik-Tandem) was constructed in the Institute's production training school. It was exhaustively tested by P M Stefanovskii from 5th December 1937. Once the dangerously inadequate directional (yaw) stability had been corrected, by adding fins and rudders above the tailplane, the aircraft flew well. Eventually it was judged to be unreliable and not really needed, but a derivative with armour, an M-82 engine and a cannon in the turret might have proved very useful.

Left: Two views of Sh-Tandem as originally built.

Opposite page: Sh-Tandem after modification

Sh-Tandem
(upper side view as
originally built).



The key feature of this aircraft was that it had a main wing and a rear wing with 45 per cent as much area, both having R-11 aerofoil profile. After experimenting with elevens the control surfaces on the rear wing were linked to move in unison as elevators, all lateral control being by the ailerons on the main wing. Fins and rudders were fitted at 50 per cent of the semi-span on the rear wing, initially on the underside only in order to leave a clear 250° arc of fire for the electrically driven turret with a ShKAS. Four more ShKASs were to be fixed firing ahead from the main wing, but these cannot be seen in photographs. An internal bay housed a 200kg (441 lb) bombload. The engine was an M-87 (derived from the

Gnome-Rhone K14) radial rated at 930hp. The tailwheel was fixed but the neat main units had single legs and retracted into the wing. The airframe was constructed mainly of wood, with skins of delta bakelite-impregnated veneer. Other features included a three-blade variable-pitch propeller, Hucks starter dogs on the propeller shaft, cooling

gills behind the engine cowling, a ventral ducted oil cooler (repeatedly modified) and aft-sliding pilot's canopy.

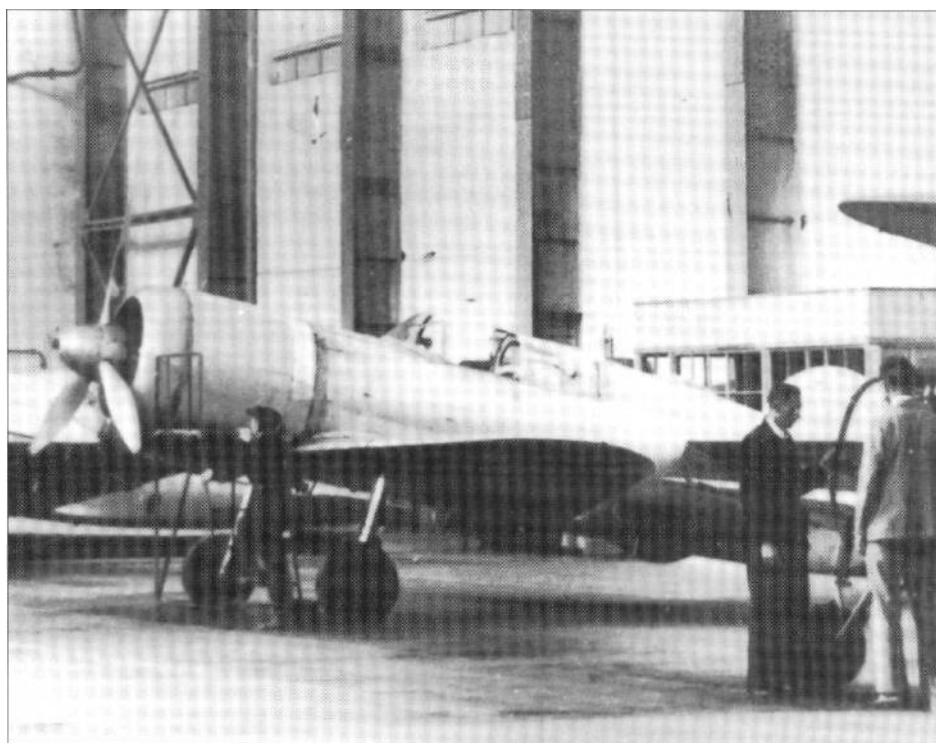
Despite its extraordinary appearance this aircraft was clearly basically successful. Whether a developed version could have done better than the Ilyushin Shturmovik is problematical.

| | | |
|-------------------|--------------------|---------------------|
| Dimensions | | |
| Span (main wing) | 11.0m | 36 ft 114 in |
| (rear wing) | 7.0m | 23ft |
| Length | 8.5m | 27 ft <i>M</i> in |
| Wing area (total) | 30.4m ² | 327 ft ² |

| | | |
|---------------------------|-----------|----------|
| Weights | | |
| Empty | not known | |
| Loaded given variously as | 2,560kg | 5,644 lb |
| and, more likely, as | 3,088 kg | 6,808 lb |

| | | |
|------------------------|----------|---------|
| Performance | | |
| Max speed at sea level | 406 km/h | 252 mph |
| at 4,200m (13,780 ft) | 488 km/h | 303 mph |

No other data.



Gudkov Gu-1

Purpose: To create a more manoeuvrable fighter.

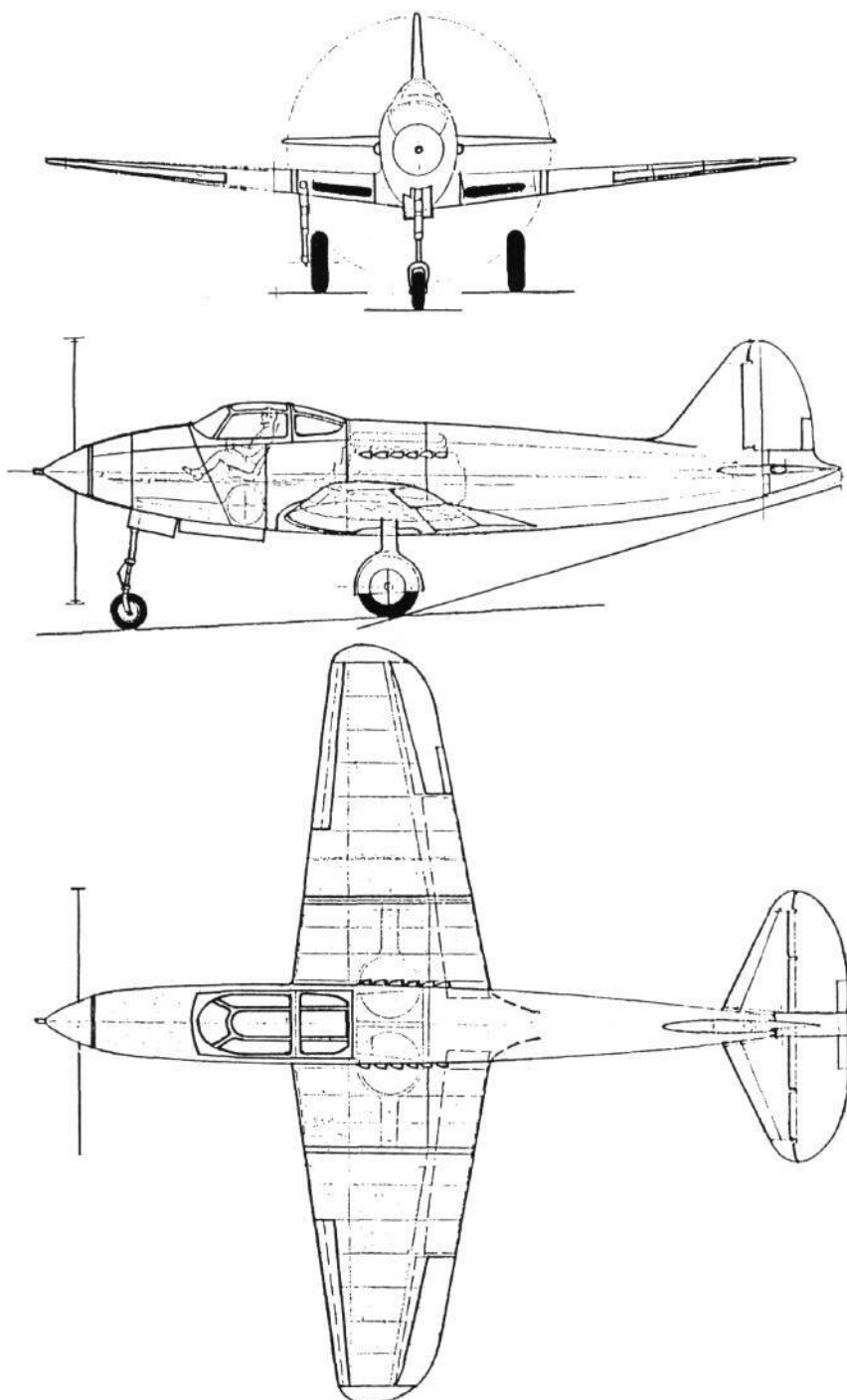
Design Bureau: Brigade led by Mikhail Ivanovich Gudkov, Moscow.

Gudkov was one of the three partners who created the LaGG design bureau, later led by Lavochkin only. In early 1940 Gudkov became convinced that the Bell P-39 Airacobra, with the engine behind the cockpit, had a superior configuration. It gave the pilot a better view, and by placing the heavy engine in the centre of the aircraft greatly reduced the long-

itudinal moment of inertia, and thus should improve manoeuvrability. As well as working on supposed improved derivatives of the LaGG, Gudkov managed to obtain funding for a mid-engined fighter in early 1942, as well as a contract with the A A Mikulin bureau for the supply of an engine. The resulting Gu-1, also called the Gu-37, was completed in the early summer of 1943. After prolonged taxi trials test pilot A I Nikashin said 'It seems glued to the ground'. On 12th June 1943 Nikashin attempted the first flight. The Gu-1 reached about 200m (650ft) but then appeared to sideslip into the ground, Nikashin being killed. Gudkov's brigade was disbanded.

The configuration followed the Airacobra exactly, with the major difference that the Gu-1 was constructed largely of wood, with bakelite-ply skin. Metal parts included the fuselage back to the firewall between the cockpit and engine (aligned with the front spar), which was based on a steel-tube truss with skin of removable D1 panels, D1 wing spars and D1 control surfaces. The wing was of IV-10 Type V-2 aerofoil profile, and was fitted with automatic leading-edge slats and hydraulically driven split flaps. The engine was an AM-37 rated at 1,380hp (the designer's notes on the preliminary drawing show that he wanted an AM-41). Carburettor inlets were in the wing roots, and long inlets further outboard served the radiators inside the wing ahead of the inwards-retracting main landing gears. The drive was taken through a steel tube of 120mm (4in) diameter to the reduction gear in the nose. The long nose gear retracted back into a bay in the lower part of the nose. Armament comprised a massive Taubin 37mm cannon firing through the propeller hub, fed by an 81-round magazine (surprisingly large for this calibre) and six ShKAS machine guns in the fuselage and wing roots.

Few documents on the Gu-1 have been found. One is led to conclude that either the wing or vertical tail was too small, or possibly both.



OKB drawing of Gu-1

Dimensions

| | | |
|-----------|---------------------|---------------------|
| Span | 10.0m | 32 ft 9 9/16 in |
| Length | 10.68m | 35 ft 4 1/8 in |
| Wing area | 20.0 m ² | 215 ft ² |

Weights

| | | |
|--------|---------|-----------|
| Empty | 3,742kg | 8,250 lb |
| Loaded | 4,610kg | 10,163 lb |

Performance

| | | |
|--------------------------|----------|---------|
| Landing speed (estimate) | 195 km/h | 121 mph |
|--------------------------|----------|---------|

No other data.

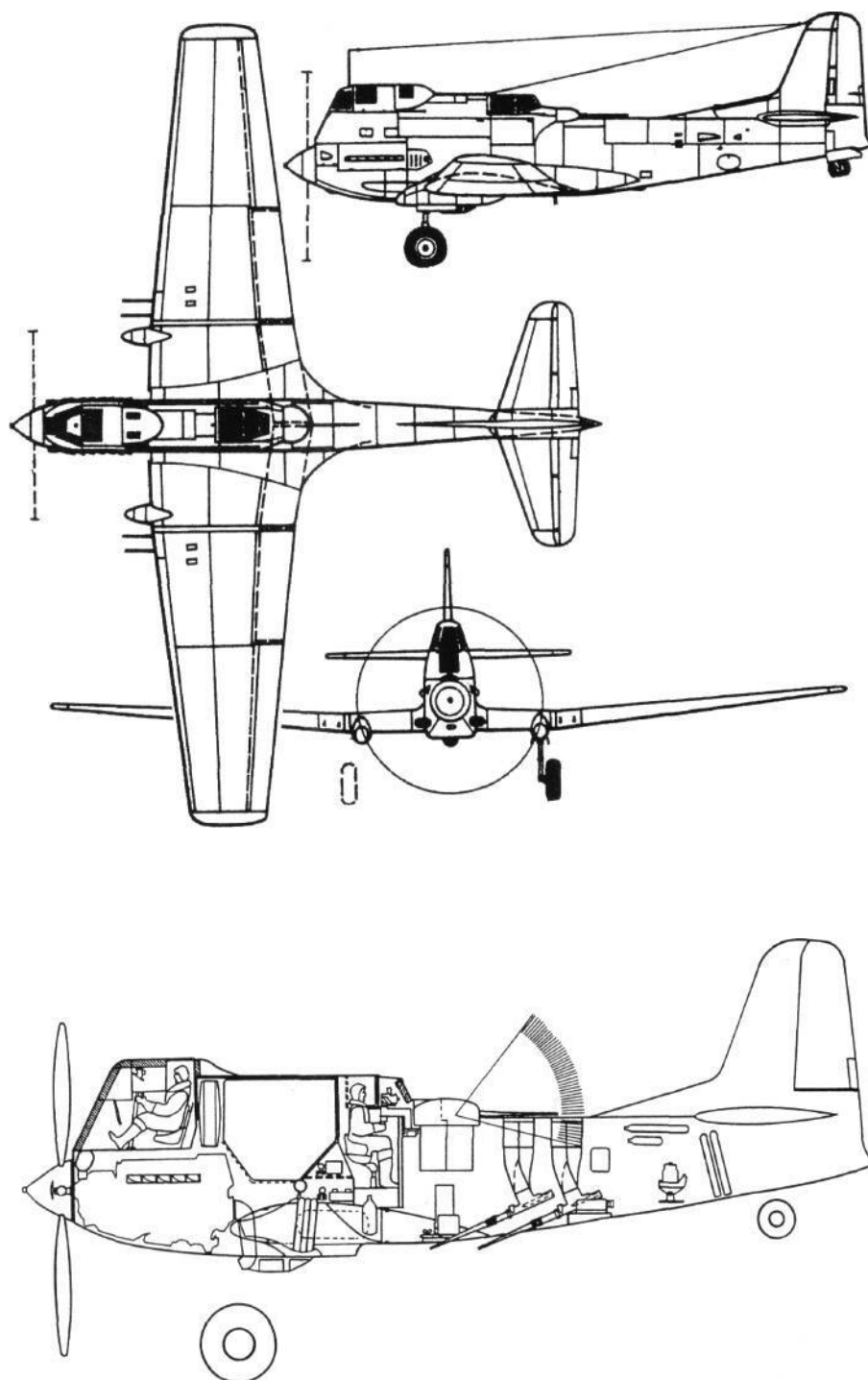
Ilyushin IL-20

Purpose: To design an improved Shturmovik attack aircraft.

Design Bureau: OKB of Sergei Ilyushin, Moscow.

In the Great Patriotic War Ilyushin became famous, even outside the Soviet Union, mainly because of his IL-2 Shturmovik (assault). No fewer than 36,163 were delivered, the greatest production run of any single type of aircraft. One reason why so many were needed was that attrition was severe, despite their heavy armour. With the IL-10M Ilyushin fractionally improved flight performance, and by 1945 the availability of more powerful engines opened the way to a further increase in gross weight. In turn this made it possible to rethink the armament, in particular adding a more effective rear defence. The single IL-20 - dubbed Gorboon, hunchback - began flight testing in 1948, but by this time piston-engined aircraft for front-line use were becoming outdated. Ilyushin dropped the IL-20 and began work on the IL-40 twin-jet Shturmovik, as well as jet bombers and other types.

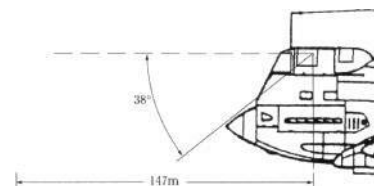
The IL-20 was a direct extrapolation of the IL-10 and related types, with similar all-metal stressed-skin construction. A basic shortcoming of the wartime Shturmoviks had been that, in most low-level attacks with bombs, the target disappeared under the nose before the bombs could be released. Ilyushin had spent much time trying to devise ways of giving the pilot a better forward view. In 1942 he had tried putting the pilot in the nose, with a shaft drive from an engine behind the cockpit, but dropped this idea. Various laboratories also failed to find good answers, one being the PSh periscopic sight. In 1946 he tried the even more unusual scheme of putting the pilot directly above the engine. The latter was an AM-47F (also called MF-47) liquid-cooled V-12, the last of Mikulin's big piston engines, rated at 3,100hp, driving a 3.2m (10ft 6in) four-blade propeller. Despite being protected below by armour and with the cockpit above, the engine was said to be readily accessible and removable. The pilot had a cockpit with armour 6 to 9mm thick, with a field of view directly ahead up to 37° downwards, so that in a shallow dive he had a perfect view of the target. Behind the cockpit was a large protected tank, and behind that a radio operator in a powered turret with an NR-23 cannon. The main landing gears retracted aft in the usual manner, the wheels rotating 90° to lie flat in the wings. Immediately outboard of these were four NS-23 cannon firing ahead. In one scheme; illustrated on this page, two further NS-23 were fixed obliquely in the rear fuselage firing ahead and

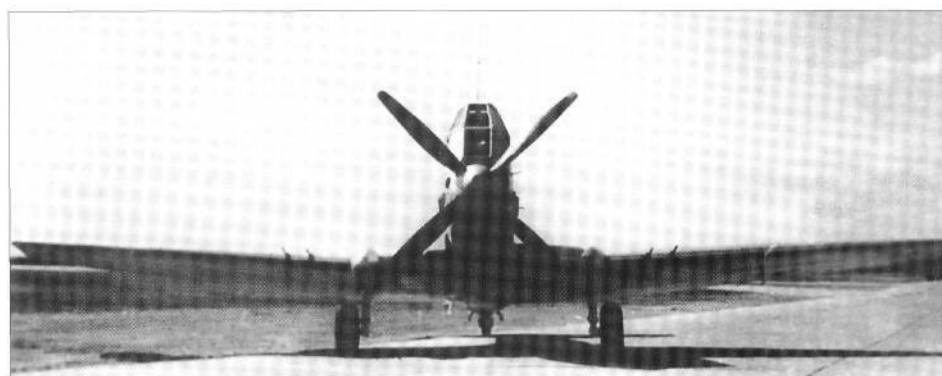
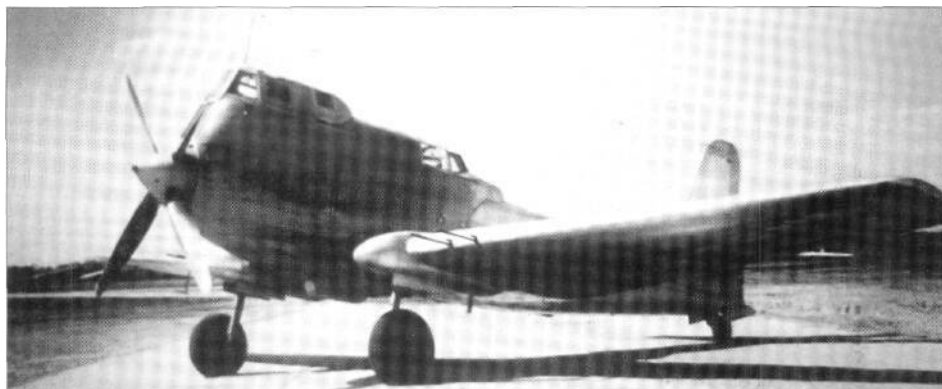


Top: IL-20.

Above: IL-20 armament.

Right: IL-20 pilot view.





downwards. A bomb load of up to 1,190kg (2,623.5 lb) could be carried in wing cells, and wing racks were provided for eight RS-82 or four RS-132 rockets. There was also to have been an anti-submarine version, never built.

Though clearly a formidable aircraft, the IL-20 actually had a flight performance in almost all respects inferior to that of the wartime IL-10. Ilyushin was certainly right to abandon it, and in fact the basic attack role was later assumed by the simple MiG-15 single-seat fast jet.

| Dimensions | | |
|-----------------------------|--------------------|---------------------|
| Span | 17.0m | 55 ft 9 in |
| Length | 12.59m | 41 ft 3% in |
| Wing area | 44.0m ² | 474 ft ² |
| Weights | | |
| Empty | 7,535 kg | 16,612 lb |
| Fuel/oil | 800+80 kg | 1,764+176 lb |
| Loaded normal | 9,500 kg | 20,944 lb |
| Maximum | 9,820 kg | 21,649 lb |
| Performance | | |
| Maximum speed | | |
| at sea level | 450 km/h | 280 mph |
| at 2,800m (9,186 ft) | 515 km/h | 320 mph |
| Time to climb to 3,000 m | 8min | 9,843 ft |
| to 5,000 m | 12.5min | 16,404ft |
| Service ceiling | 7,750m | 25,430ft |
| Range (normal gross weight) | 1,180 km | 733 miles |
| (maximum weight) | 1,680 km | 1,044 miles |
| Take-off run | 500m | 1,640ft |
| Landing speed | 150 km/h | 93 mph |

Three views of IL-20.

Kalinin K-7

Purpose: To create a super-heavy bomber.

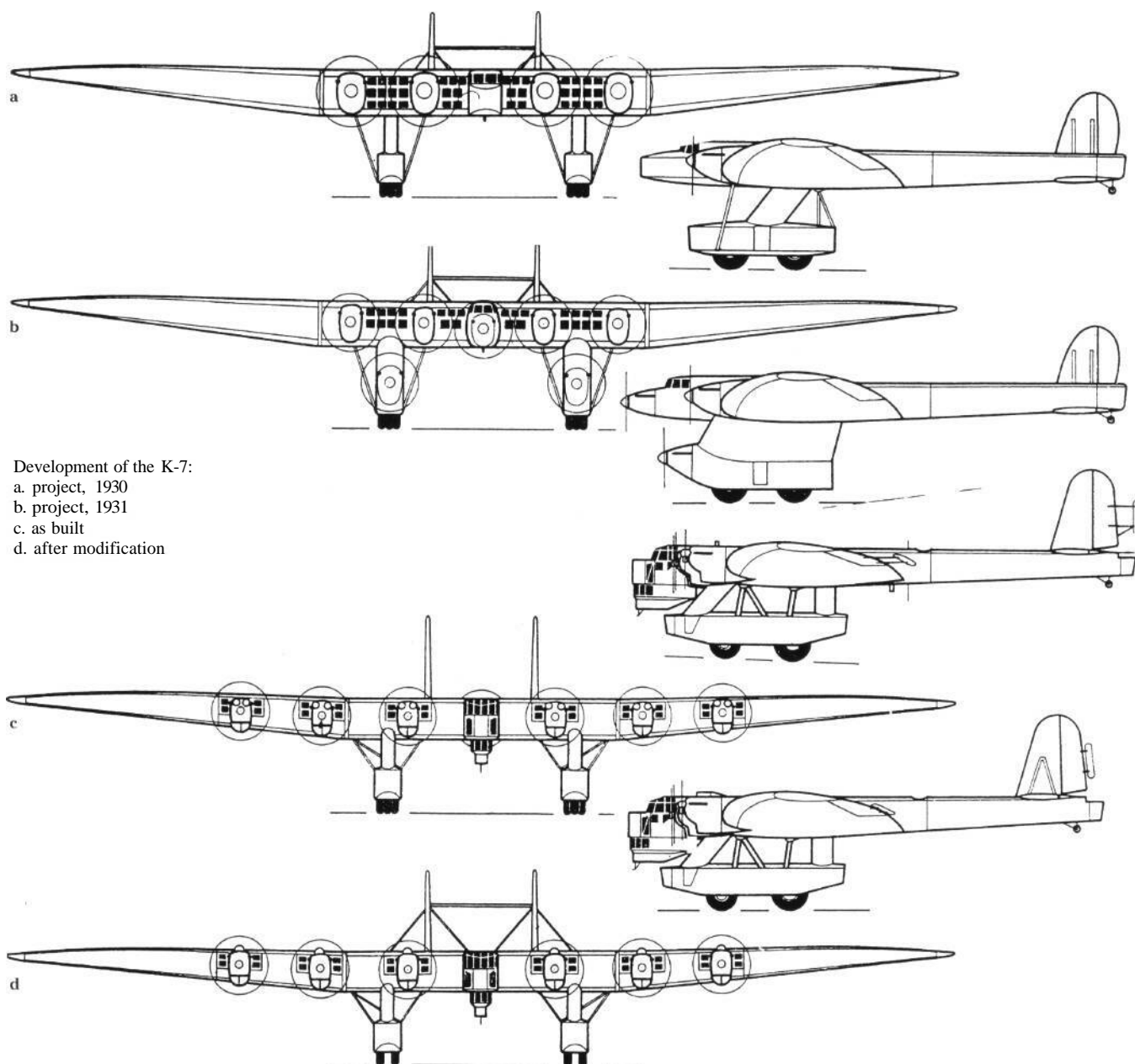
Design Bureau: OKB of K A Kalinin, Kharkov.

From 1925 Kalinin made himself famous with a series of single-engined aircraft characterised by having a quasi-elliptical monoplane wing. In 1930 he sketched a gigantic transport aircraft, the K-7, with a tail carried on two booms and with four 1,000hp engines mounted on the wing, which was deep enough to house 60 passengers or 20 tonnes of cargo. No engine of this power was readily available, so in 1931 he redesigned the aircraft to have seven engines of (he hoped) 830hp. GUAP (the Ministry of Aviation Industry) gave permission for the aircraft to be built, but with the role changed to a heavy bomber. This meant a further total redesign, one

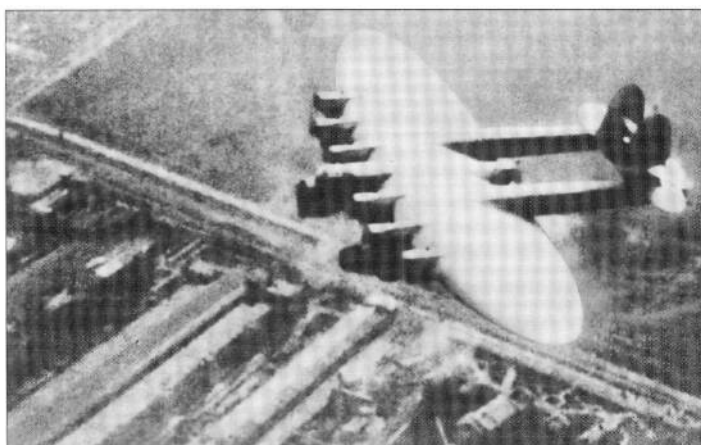
change being to move the centreline engine to the trailing edge. This near-incredible machine was completed in summer 1933. Ground running of the engines began on 29th June, and it was soon obvious from serious visible oscillation of the tail that the booms were resonating with particular engine speeds. The only evident solution was to reinforce the booms by adding steel angle girders, and brace the tail with struts. Flight testing by a crew led by pilot M A Snegiryov began on 11th August 1933, causing intense public interest over Kharkov. On Flight 9, on 21st November, during speed runs at low altitude, resonance suddenly struck and the right tail boom fractured. The aircraft dived into the ground and burned, killing the pilot, 13 crew and a passenger; five crew survived. Kalinin was sent to a new factory at Voronezh. Here

a plan was organised by P I Baranov to build two improved K-7s with stressed-skin booms of rectangular section, but this scheme was abandoned in 1935, the K-7 no longer being thought a modern design.

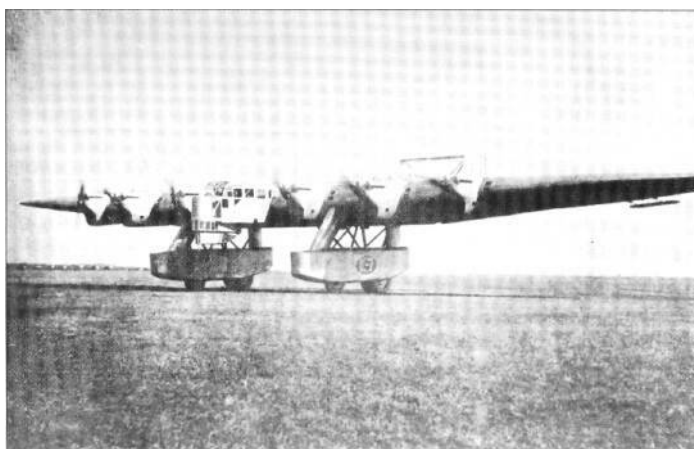
The basis of this huge bomber was the enormous wing, of typical Kalinin plan form. It had CAHI (TsAGI) R-II profile, with a thickness/chord ratio of 19 per cent, rising to 22 per cent on the centreline, where root chord was 10.6m (34ft 9%in) and depth no less than 2.33m (7ft 7%in). The two main and two subsidiary spars were welded from KhMA Chromansil high-tensile steel, similar lattice girder construction being used for the ribs. The wing was constructed as a rectangular centre section, with DI skin, and elliptical outer sections covered mainly in fabric. A small nacelle of DI stressed-skin construction projected from



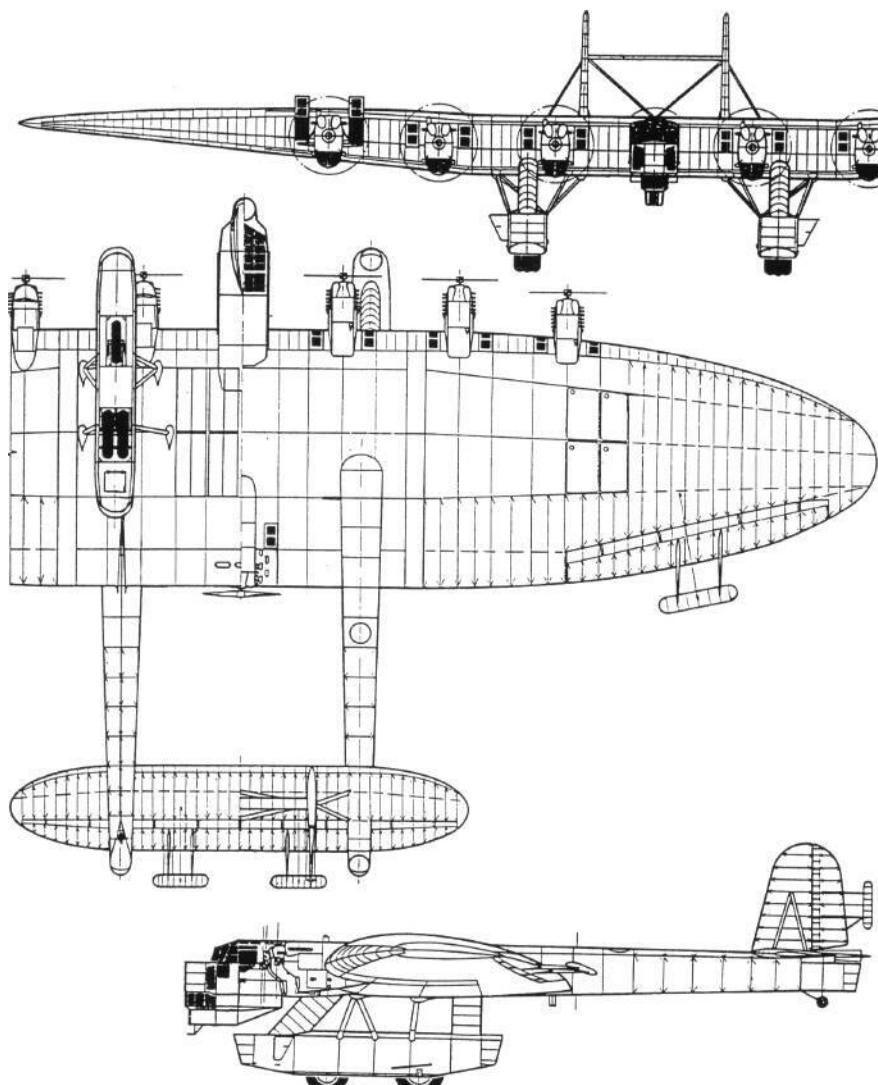
K-7 over Kharkov.



A view of the modified aircraft.



K-7 final form



the leading edge. On the leading edge were six 750hp M-34F water-cooled V-12 engines, each with a radiator underneath, and driving a two-blade fixed-pitch propeller; a seventh engine was on the trailing edge. Walkways along the wing led to each engine, and on the ground mechanics could open sections of leading edge to work on the engines without needing ladders. Metal tanks in the wings housed 9,130 litres (2,008 Imperial gallons, 2,412 US gallons) of fuel. Just outboard of the innermost engines were the booms holding the tail, 11.0m (36ft P/in) apart, each having a triangular cross-section with a flat top. The elliptical horizontal tail carried twin fins and rudders 7.0m (22ft 11 Jin) apart. All flight controls were driven by large servo surfaces carried downstream on twin arms. Under the wing, in line with the booms, were extraordinary landing gears. Each comprised an inclined front strut housing a staircase and a vertical rear strut with an internal ladder. At the bottom these struts were joined to a huge gondola. Each gondola contained three large wheels, one in front and two behind, holding the aircraft horizontal on the ground. In front of and behind the front wheels were bomb bays with twin doors. Maximum bomb load was no less than 19 tonnes (41,887lb). Defensive armament comprised a 20mm cannon in a cockpit in the nose, two more in the ends of the tail booms and twin DA machine guns aimed by gunners in the front and rear of each gondola. Total crew numbered 11, all linked by an intercom system.

Though a fantastic and deeply impressive aircraft, the K-7 was flawed by its designer's inability to solve the lethal problem of harmonic vibration. Even without this, it would probably have been a vulnerable aircraft in any war in which it might have taken part.

Dimensions

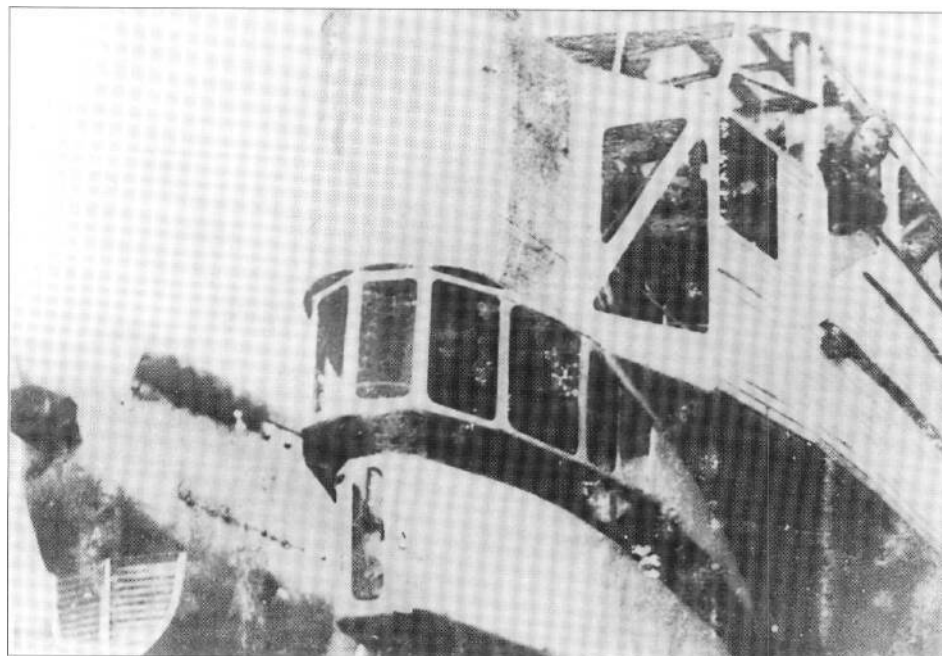
| | | |
|-----------|-------------------|----------------------|
| Span | 53.0m | 173 ft W. in |
| Length | 28.184m | 92 ft 554 in |
| Wing area | 454m ² | 4,887ft ² |

Weights

| | | |
|-----------------|---------------|----------------|
| Empty | 24,400kg | 53,792 lb |
| Fuel/oil | 6,500+ 600 kg | 14,330+1,323lb |
| Loaded (normal) | 38,000 kg | 83,774 lb |
| (maximum) | 46,500 kg | 102,513lb |

Performance

| | | |
|------------------------|------------|-------------|
| Maximum speed (design) | 225 km/h | 140 mph |
| (achieved) | 204.5 km/h | 127 mph |
| Long-range speed | 180 km/h | 112 mph |
| Service ceiling | 3,630m | 11,910ft |
| Normal range | 3,030 km | 1,883 miles |



Nose of the modified aircraft.

Kalinin K-12

Purpose: To create a multirole aircraft with tailless configuration.

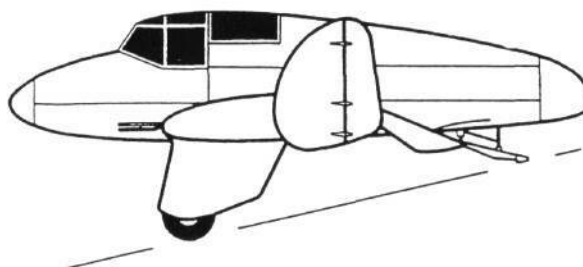
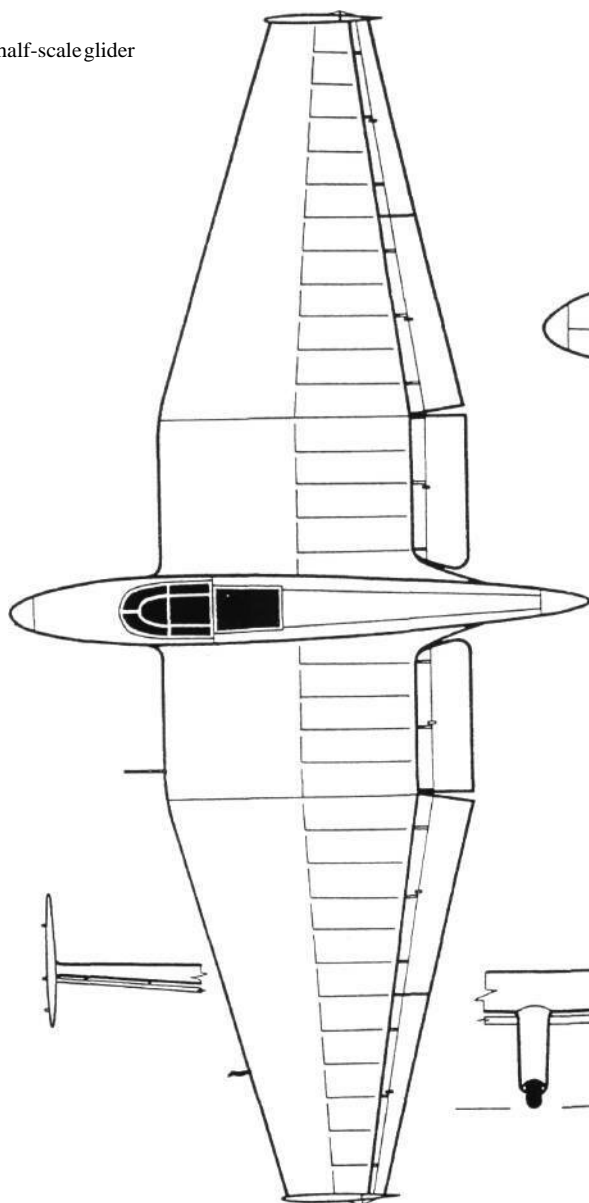
Design Bureau: OKB of K A Kalinin, Voronezh.

In April 1933 Kalinin submitted to the NII-WS three preliminary designs for a VS-2 (Voiskovoi Samolyot, troop aircraft) for reconnaissance, bombing, transport, ambulance and other missions. One was conventional, the second had twin tail booms, and the third was tailless. Kalinin preferred the third option, because of supposed lower weight and drag, better manoeuvrability and ease of fitting a tail turret for defence. He began with the NACA-106R aerofoil, with slats, park-bench

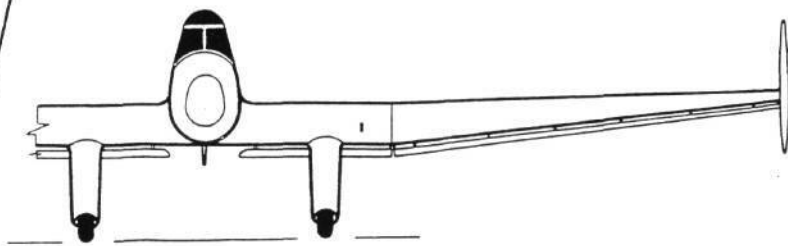
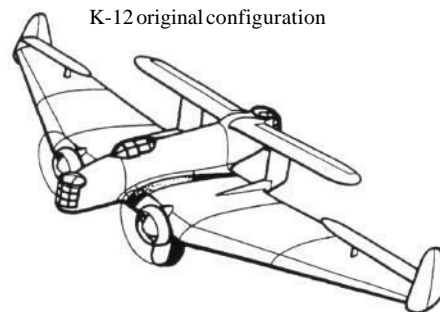
ailerons, Scheibe wingtip rudders and a vestigial horizontal tail. Tunnel testing of models led to an improved design with a trapezoidal wing of CAHI (TsAGI) R-II profile, with trailing-edge servo-operated elevators and ailerons of Junkers 'double wing' type (as also used by Grokhovskii), the small horizontal tail being eliminated. To test the configuration a half-scale glider (span 10.45m, length 5.2m) was constructed in 1934 and flown over 100 times by V O Borisov. After many problems and arguments, the full-scale aircraft was completed at GAZ (State Aviation Factory) No 18 at Voronezh as the K-12, and flown by Borisov in July 1936. Factory testing was completed in 46 flights. The K-12 was then ferried to

Moscow where its NII testing was assigned to P M Stefanovskii from October 1936. He found severe control problems, and eventually N N Bazhanov, head of the NII-WS, refused to accept the K-12 for official trials. From this time onwards Kalinin was under a cloud. The Director of GAZ No 18 joined with Tupolev, Vakhmistrov (see later) and others to impede progress and get the K-12 abandoned. Kalinin moved into Grokhovskii's summer dacha, the K-12 languishing at Grokhovskii's KB-29. Contrary to the political tide, Voroshilov ordered the K-12 to fly in the 1937 Air Day parade over Moscow Tushino, and Bazhanov had it painted in a fantastic red/yellow feathered scheme as the Zhar

K-12 half-scale glider



K-12 original configuration



Ptitsa (firebird or phoenix). It made a great impression, and on 12th December 1937 the Assistant Head of the WS, YaVSmushkevich, signed an order for renewed NII-WS testing to start on 1st March 1938, followed by series production of modified aircraft at GAZ No 207. Work began, but in spring 1938 Kalinin's enemies managed to get him arrested and shot on charges of spying and conspiracy. As he had become an 'enemy of the people' the contract was cancelled, the K-12 was scrapped and the ten aircraft on the assembly line were never completed.

The structure of the K-12 was almost entirely based on welded KhMA (Chromansil steel) tubing. The wing comprised left and right panels bolted to the roots, each having one main spar running straight from tip to tip. The fuselage was in three bolted sections, the front section being mainly skinned in D1, all the rest of the skin being fabric. The trailing-edge and wingtip controls were all fabric-skinned D1. The main landing gears were to have been retractable, but the intended M-25 engines and variable-pitch propellers were not available in time, so weight was saved by making the landing gears fixed. The inadequate engines which had to be fitted were 480hp M-22 (Bristol Jupiter licence), in cowlings with cooling gills, and driving 2.8m

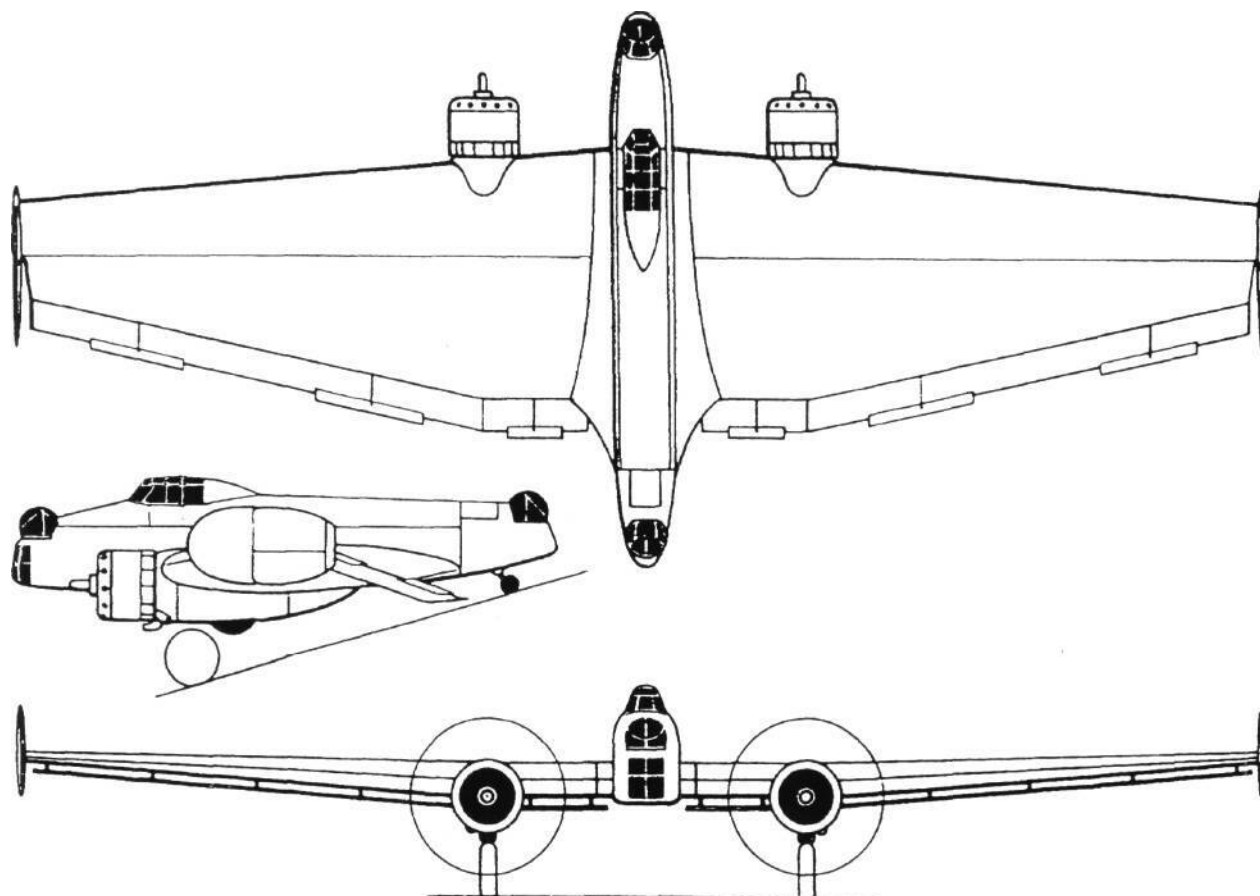
(9ft 2 $\frac{1}{2}$ in) two-blade metal propellers with pitch adjustable on the ground. Crew comprised a pilot in an enclosed cockpit, a navigator who also served as bomb aimer in a nose turret with one 7.62mm ShKAS (he was provided with a rudimentary flight-control lever in case the pilot was incapacitated) and a radio operator in a similar tail turret. Bombload of up to 500kg (1,102lb) was carried on a KD-2 vertical rack behind the main spar and pilot's cockpit. Other equipment included a VSK-2 radio and AFA-12 camera.

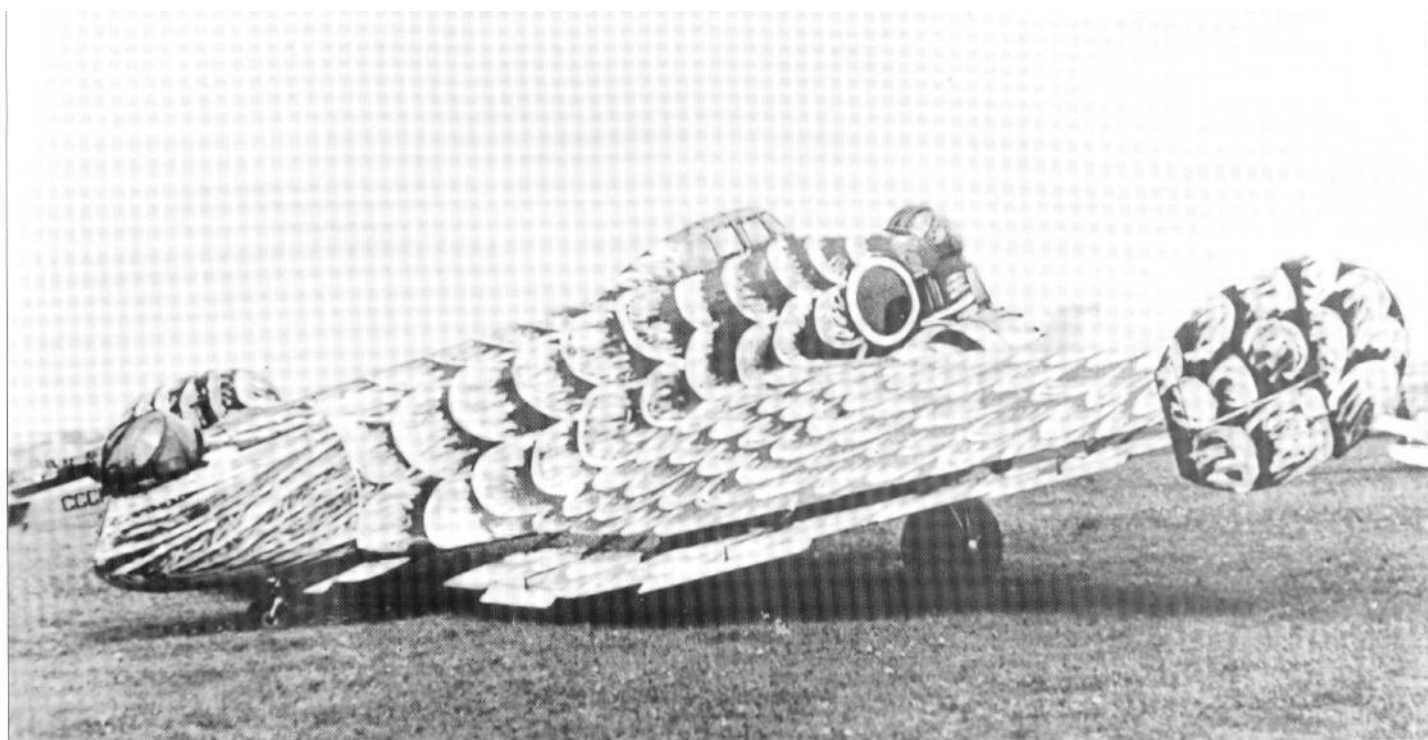
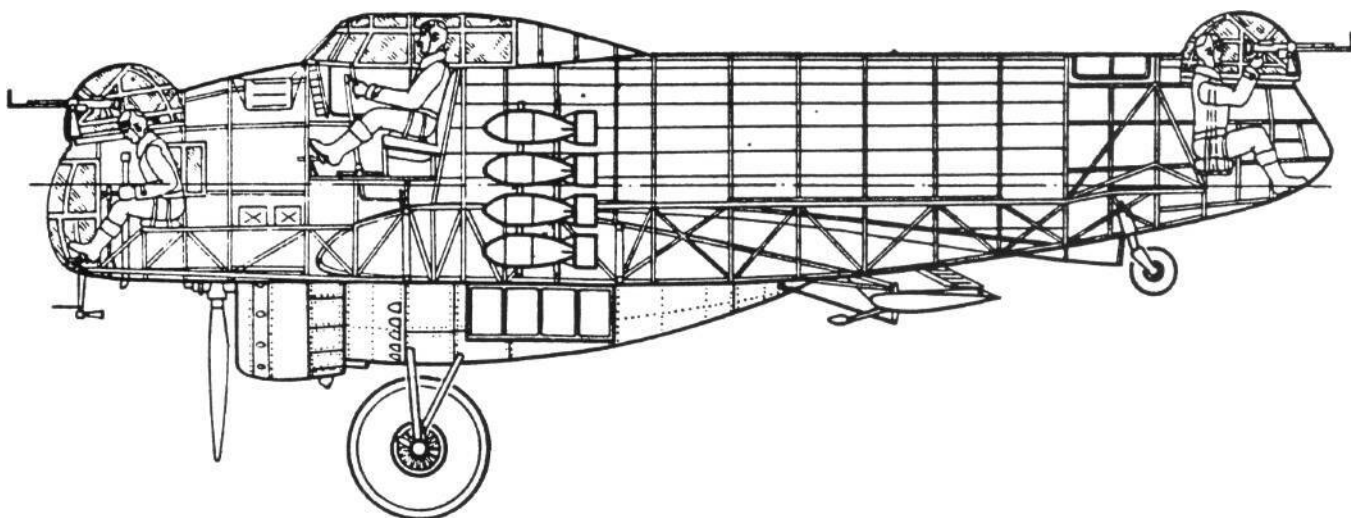
At the end of its life, in early 1938, the K-12 was refitted with 700hp M-25 (Wright Cyclone) engines, driving Hamilton Standard type variable-pitch propellers, but it was never tested in this form. Other modifications included fitting an electrically retractable main landing gear and modified armament. It had also been Kalinin's intention to replace the wingtip fin/rudder surfaces by rudders above the wings behind the engines, but these were never fitted.

Accounts of this strange tailless aircraft tend either to be strongly positive or strongly negative. There is no doubt Kalinin was the victim of political intrigue, but at the same time the K-12 does not appear to have been a stable or controllable aircraft.

| Dimensions (As flown with M-22 engines) | | |
|---|---------------------|---------------------|
| Span | 20.95m | 68 ft 8in |
| Length | 10.32m | 33 ft 11 in |
| Wing area | 72.75m ² | 783 ft ² |
| Weights | | |
| Empty | 3,070kg | 6,768 lb |
| Fuel/oil | 500kg | 1,102 lb |
| Loaded | 4,200kg | 9,259 lb |
| Performance | | |
| Maximum speed | 219km/h | 136 mph |
| Service ceiling | 7,170m | 23,524ft |
| Range | 700km | 435 miles |
| Take-off run | 700m | 2,297ft |
| Landing run | 300m | 984ft |

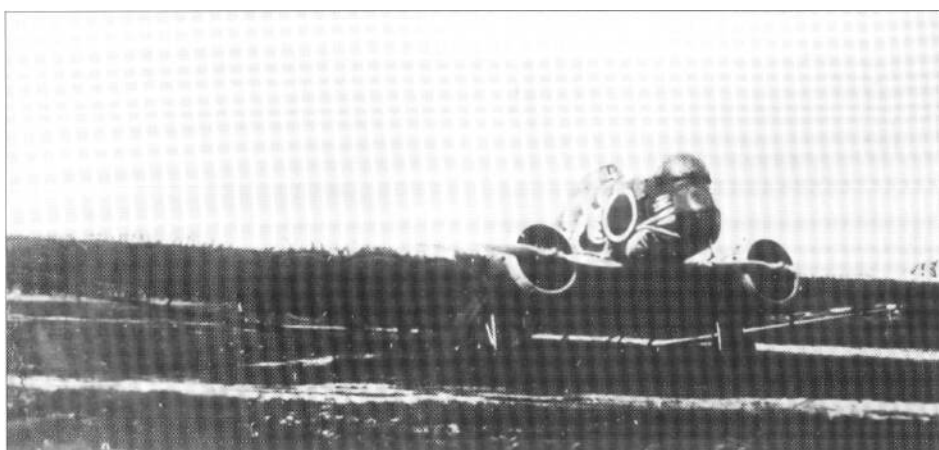
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Top: K-12 inboard profile.

Above and right: Two views of Zhar Ptitsa.



Kamov Ka-22

Purpose: To create a Vintokryl (screw wing) compound helicopter.

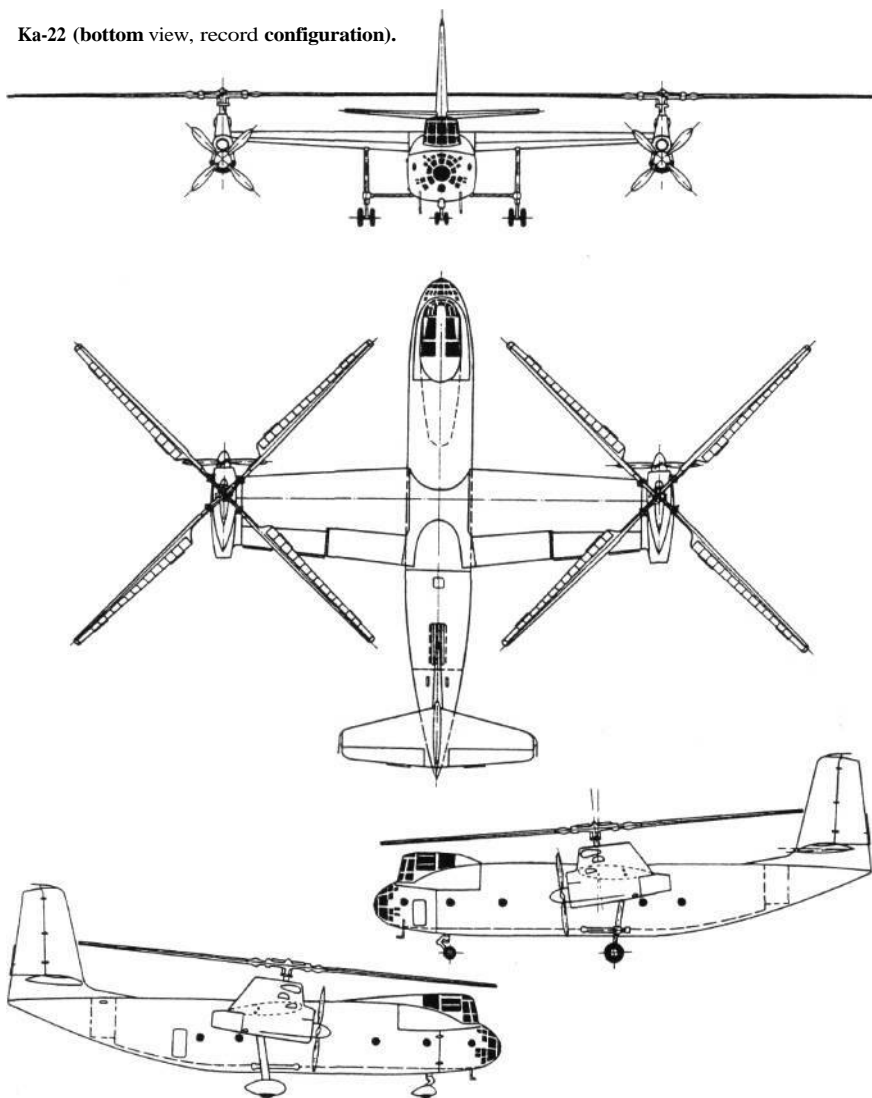
Design Bureau: OKB of Nikolai Kamov, Moscow.

In 1951 various attempts were being made to increase the effective range of helicopters, notably by towing them in the outward direction behind an Li-2, with the lifting rotor autorotating. The idea occurred to Kamov designer Vladimir Barshevsky that it would be possible to dispense with the tug aircraft if a helicopter could be provided with wings and an aeroplane propulsive system. After obtaining permission from Kamov, his deputy V V Nikitin took a proposal to the Kremlin and in a matter of days the OKB had a Stalin directive to get started. The engines were to be TV-2 (later TV-2VK) turboshafts supplied by N D Kuznetsov, and many organizations were involved in research for this challenging pro-

ject, starting with model tests in the T-101 tunnel at CAHI. The final go-ahead was issued on 11th June 1954. An order for three Ka-22s was placed on the factory at Ukhtomskaya, which had been derelict since Kamov was evacuated from there in October 1941. Concentration on the small Ka-15 (the OKB's first production helicopter) and other problems so delayed the programme that on 28th March 1956 prototypes 2 and 3 were cancelled. In June 1958 the LD-24 rotor blades began testing on an Mi-4. The Ka-22 itself first lifted from the ground on 17th June 1959, and made its first untethered flight on 15th August 1959, the test crew being led by pilot D K Yefremov. Serious control difficulties were encountered, and the Kamov team were joined by LII pilots V V Vinitskii and Yu A Garnayev. Though still full of problems the Vintokryl was demonstrated on 11th October 1959 to MAP Minister P V Dement'yev and WS C-in-C

KAVershinin. Gradually difficulties were solved and in July 1960 an order was received to manufacture three Ka-22s at GAZ No 84 at Tashkent, with D-25VK engines. On 23rd May 1961 a speed of 230km/h was held for 37 minutes. On 9th July 1961 the Ka-22 caused a sensation at the Aviation Day at Tushino. On 7th October 1961, with spats over the wheels and a fairing behind the cockpit, a class speed record was set at 356.3km/h (221.4mph), followed on 12th October by 336.76km/h (209.3mph) round a 100km circuit. The spats and fairing were then removed and on 24th November 1961 a payload of 16,485kg (36,343 lb) was lifted to 2,557m (8,389ft). Preparations were then made to ferry AM 01-01 and the third machine AM 01-03 from Tashkent to Moscow for Nil acceptance testing. Both departed on 28th August 1962. While making an intermediate stop at Dzhuzaly 01-01 rolled to the left and crashed inverted, killing Yefremov and his crew of six. The cause was diagnosed as 'disconnection of No 24 cable joint of the linkage with the starboard lift rotor collective-pitch control unit'. At Tashkent and in Turkistan the cable joints and cyclic-pitch booster brackets were inspected on 01-02 and 01-03 and found to be incorrectly assembled. Changing the direction of rotation of one lifting rotor did little at lower speeds and caused problems at higher speeds - 'When', said lead engineer V S Dordan, 'Shockwaves off the blades sounded like a large machine gun'. To improve stability and controllability the complex AP-116 differential autopilot was installed, continuously sensing attitude and angular accelerations, feeding the KAU-60A combined flight-control unit. On 12th August 1964 the heavily instrumented 01-03 took off on one of a series of tests conducted with WS (air force) and GVF (civil) crews. Take-off was in aeroplane mode, and 15 minutes later at 310km/h (193mph) the aircraft suddenly turned to the right, 'not arrested by full rudder and aileron...the aircraft turned almost 180° when Garnayev intervened, considering the problem was differential pitch of the propellers...turn rate slowed, but the aircraft pitched into a steep dive...the engineer jettisoned the flight-deck hatches, and one struck the starboard lift rotor causing asymmetric forces which resulted in separation of the entire starboard nacelle. Garnayev ordered the crew to abandon the aircraft'. Three survived, but Col S G Brovtsev, who was flying, and technician A F Rogov, were killed. By this time the Mi-6 heavy helicopter was in wide service, and the Ka-22 was ultimately abandoned. Several years later the two surviving machines, 01-02 and 01-04, were scrapped.

Ka-22 (bottom view, record configuration).



An article about the Ka-22 in Kryl'ya Rodiny (Wings of the Motherland) for November 1992 does not mention the fact that two crashed, which is not widely known even in the former Soviet Union.

The Ka-22 was basically an aeroplane with its engines on the wingtips, with geared drives to both propellers and lifting rotors. The airframe was all light alloy stressed-skin, the high wing having powered ailerons and plain flaps. The fuselage had a glazed nose, three-seat cockpit above the nose and a main cargo area 17.9x3.1x2.8m (58'9" x 10'2" x 9'2") for 80 seats or 16.5 tonnes of cargo. The entire nose could swing open to starboard for loading bulky items or a vehicle. The original prototype was powered by 5,900-shp TV-2VK engines, but these were later replaced by the 5,500-shp D-25VK. These had free turbines geared via a clutch to the main-rotor and via a front drive to the four-blade propeller and a fan blowing air through the oil cooler from a circular inlet above the nacelle. The two free-turbine outputs were interconnected by a 12-part high-speed shaft 'about 20m long'. The main rotors were larger derivatives of those of the Mi-4. In helicopter mode the propeller drive was declutched and the flaps were fully lowered. Flight control was by differential cyclic and collective pitch. In aeroplane mode the lifting rotors were free to windmill and the aircraft was controlled by the ailerons and tail surfaces. The twin-wheel landing gears were fixed.

Apart from prolonged dissatisfaction with the engines, the problems with the Ka-22 were mechanical complexity, severe losses in the gearboxes and drives and the fact that each lifting rotor blew straight down on top of the wing. Similar charges could be levelled against today's V-22 Osprey.



Above: Ka-22 in speed-record configuration.

Below: Two views of Ka-22.



Dimensions

| | | |
|--|----------------------|----------------------|
| Distance between lifting-rotor centres | 23.53m | 77 ft 2 1/2 in |
| Wing area | 105m ² | 1,130ft ² |
| Diameter of lifting rotors, originally 22.8 m, later | 22.5m | 73 ft 9 1/2 in |
| Lifting-rotor area (total) | 795.2 m ² | 8,560ft ² |
| Length | 27.0 m | 88 ft 7 in |

Weights

| | | |
|-------------------|-----------|-----------|
| Empty (initially) | 25 tonnes | |
| later | 28,200 kg | 62,169 lb |
| Loaded (VTO) | 35,500 kg | 78,263 lb |
| (STO) | 42,500kg | 93,695 lb |

Performance

| | | |
|--|----------|-------------|
| Maximum speed | 375 km/h | 233 mph |
| Dynamic ceiling (VTO) | 5,500 m | 18,050ft |
| (STO) | 4,250 m | 13,944ft |
| Potential maximum range (calculated by Barshevsky) | 5,500 km | 3,418 miles |
| STO run | 300 m | 984ft |
| Landing over 25m | 130m | 426.5ft |

Kharkov KhAI Aviaviito 3, Sergei Kirov

Purpose: To create a light transport with minimum operating cost.

Design Bureau: Kharkov Aviation Institute, Aviavnito brigade led by Aleksandr Alekseyevich Lazarev.

In the 1930s several Soviet designers produced aircraft intended to demonstrate how much could be transported on the 100hp of an M-11 engine. These aircraft were as a class called Planerlyet (motor glider). This example had an unconventional configuration. It first flew on 14th September 1936, dual-controlled by V A Borodin and E I Schwartz. Eventually a control linkage was found which by 27th September enabled good turns to be made. Shavrov's account ends with The

overall conclusion of the tests at Nil GVF (civil aviation test institute) was extremely positive', but nothing came of this one-off.

The Aviavnito-3 (often incorrectly called KhAI-3) was essentially an all-wing aircraft. The wing comprised a rectangular centre section, with the uncowed engine mounted on steel tubes on the front, to which were bolted two outer panels tapered on the leading edge. Aerofoil was V-106, with a t/c ratio of 14 per cent over the centre section, which had a chord of 5.0m (16ft 5in), tapering to 7 per cent at the tips, which incorporated 8° washout. Structurally, the centre section was KhMA steel tube covered by DI Dural skin, while the outer panels were all wood, with truss ribs supporting closely spaced stringers. Along each outer edge of the centre section was a row of four seats, each front seat being for a pilot (the two pilots had to agree in advance which one should do the flying), covered by a row of sliding canopies. The flight controls comprised large unbalanced cable-operated surfaces divided into inner and outer sections to serve as ailerons and elevators. In addition, spoilers were recessed into the upper surface of each wingtip, driven by the pedals, to enable co-ordinated turns to be made. A 2m² (21.5ft²) fin and rudder were added, but it was hoped eventually to do without this. The simple rubber-sprung main landing gears had 800 x 150mm tyres with brakes, and the large tailwheel could castor ±25°. Between the

rows of seats were four DI tanks giving an 8-hour endurance. During development two additional seats were inserted on each side, pushing the pilots into noses projecting ahead of the wing. To balance these the vertical tail was significantly enlarged.

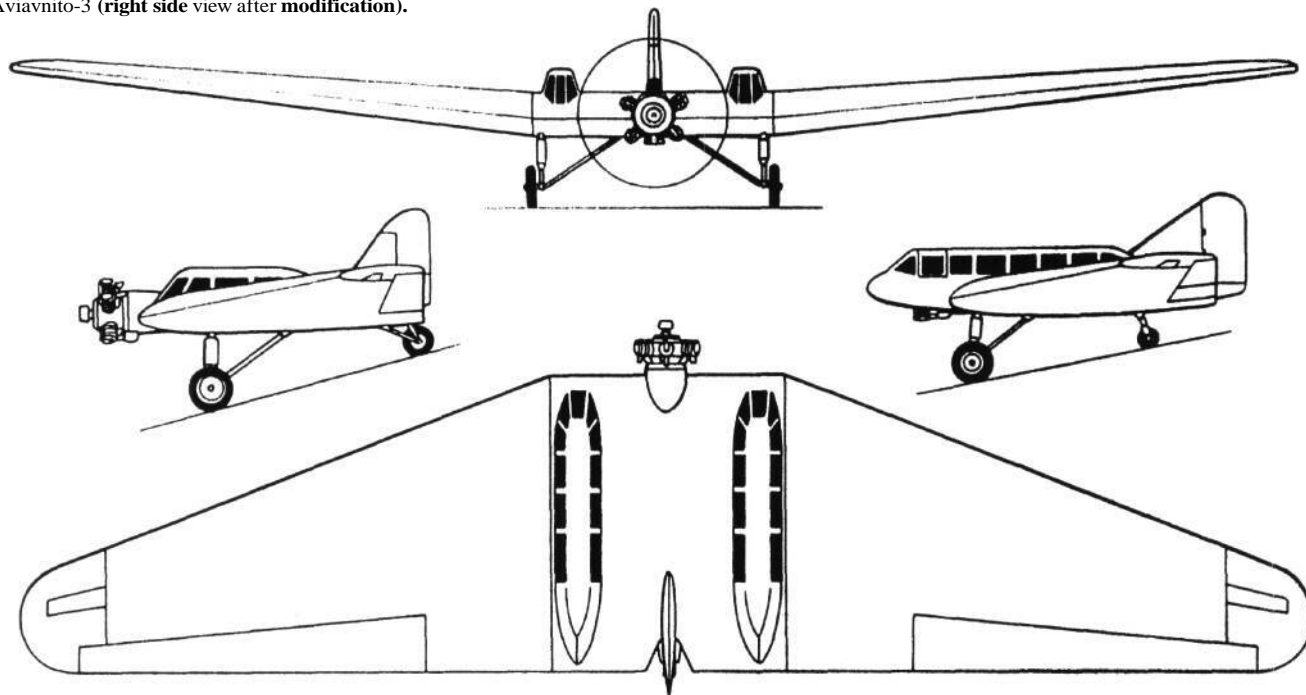
It is clear that this machine did everything expected of it, and that it was eventually developed to fly safely and controllably. However, even though they were much faster than anything else over vast areas devoid of surface transport, nothing came of the rash of Planerlyet designs.

Aviavnito-3 after modification.



| Dimensions (final form) | | |
|--------------------------|---------------------|---------------------|
| Span | 22.4m | 73 ft 6 in |
| Length | 6.8m | 22 ft 3 3/4 in |
| Wing area | 78.6 m ² | 846 ft ² |
| Weights | | |
| Empty | 1,440kg | 3,175lb |
| Fuel/oil | 200kg | 440 lb |
| Loaded | 2,200kg | 4,850 lb |
| Performance | | |
| Maximum speed | 135km/h | 84 mph |
| Cruising speed | 115km/h | 71.5 mph |
| Time to climb to 1,000 m | 25min | (3,281 ft) |
| Service ceiling approx | 2,000m | 6,561 ft |
| Range | 850km | 528 miles |
| Take-off run | 210m | 689ft |
| Landing speed | 60km/h | 37 mph |

Aviavnito-3 (right side view after modification).



Kharkov KhAI-4

Purpose: To test a tailless light aircraft.

Design Bureau: Kharkov Aviation Institute, joint design by P G Bening, A A Lazarev and AAKrol'.

Also known as the Iskra (spark) and as the Osoaviakhimovets Ukrainy for the local Osoaviakhim branch, the KhAI-4 was completed in summer 1934, and first tested in October of that year by B N Kudrin. He found the elevens almost useless, but discovered that at 150km/h (112mph) the KhAI-4 could just become airborne provided the airfield was bumpy! Once in the air he found that the downthrust of the propeller (because of its sloping thrust axis) resulted in a poor rate of climb, while the small moment arm of the elevens made longitudinal control extremely poor. To cap it all, the wingtip surfaces, away from the slipstream, were ineffective, making the aircraft directionally unstable. Kudrin was able to creep round the circuit by holding the control column neutral, and to land at high speed with a small angle of attack, not trying to raise the nose. He did fly the KhAI-4 twice more, but that was enough.

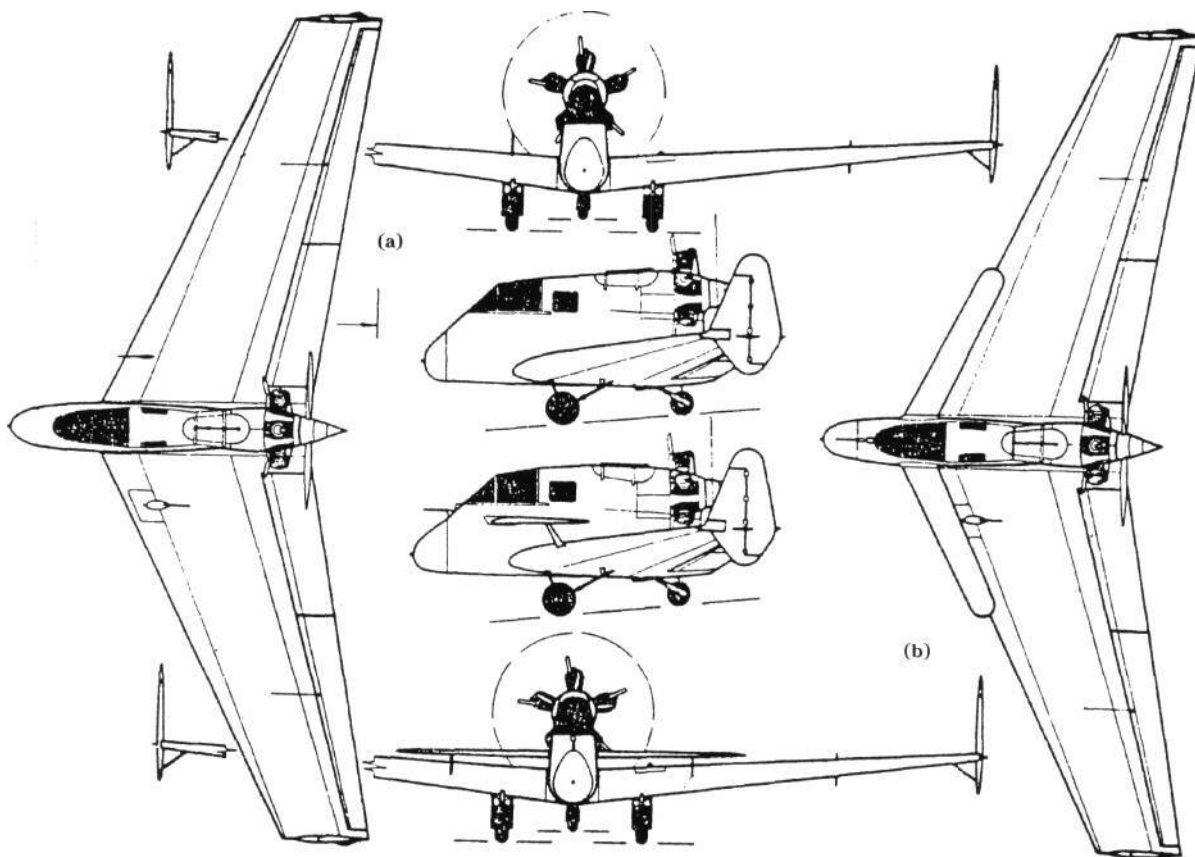
The KhAI-4 tested several ideas and even actual components which were later built into the larger Aviavnito-3. Its objective was to explore handing of a tailless machine, and also one with a castoring nosewheel (the first such landing gear in the Soviet Union). Aerodynamically it comprised a short central nacelle on a wing tapered on the leading edge, fitted with various controls. Initially the wing had six trailing-edge surfaces, all operated differentially by rotation of the pilot's hand-wheel. A push/pull movement operated the two innermost surfaces, which were thus elevens. Movement of the pedals operated rudders on the wingtip fins. Later swept-back wings with distinct ailerons and elevators were tested, and the drawing even shows the addition of small fixed foreplanes. Despite the difference in size and weight the engine was the same type of 100hp M-11 as used for the Aviavnito-3, but driving a pusher propeller. The short landing gears had balloon tyres, the main shock struts having a hydraulic connecting pipe so that, if one wheel went over a bump, the other leg would extend to hold the wings level and avoid scraping the tip. The construction was wood, but with overall fabric covering. The nacelle had two seats in tandem.

The Kharkov designers deliberately embarked on this tricky and untried layout, but failed to make it work. Dropping the idea was probably largely due to the pilot's wish to survive.



Two views of KhAI-4 (without foreplane).

| Dimensions | | |
|----------------------------|-----------|--------------------|
| Span | 12.0m | 39 ft 4H in |
| Span (new wing) | 10.9m | 35 ft m in |
| Length | 4.2m | 13 ft 9% in |
| Length (new wing) | 4.75m | 15 ft 7 in |
| Wing area | 21.25nf | 229ft ² |
| Wing area (new wing) | unchanged | |
| Weights | | |
| Empty | 550 kg | 1,213 lb |
| Empty (new wing) | 600kg | 1,323lb |
| Fuel/oil | 120kg | 265 lb |
| Loaded | 850kg | 1,874lb |
| Loaded (new wing) | unchanged | |
| Performance | | |
| Max speed attempted | 150km/h | 112 mph |
| Calculated service ceiling | 3,250m | 10,663ft |
| Design range | 600km | 373 miles |
| Landing speed | 100km/h | 62 mph |



KhAI-4: (a) with swept-back wing; (b) with a fixed foreplane.

Kharkov KhAI-2

Purpose: To build a turbojet aircraft.

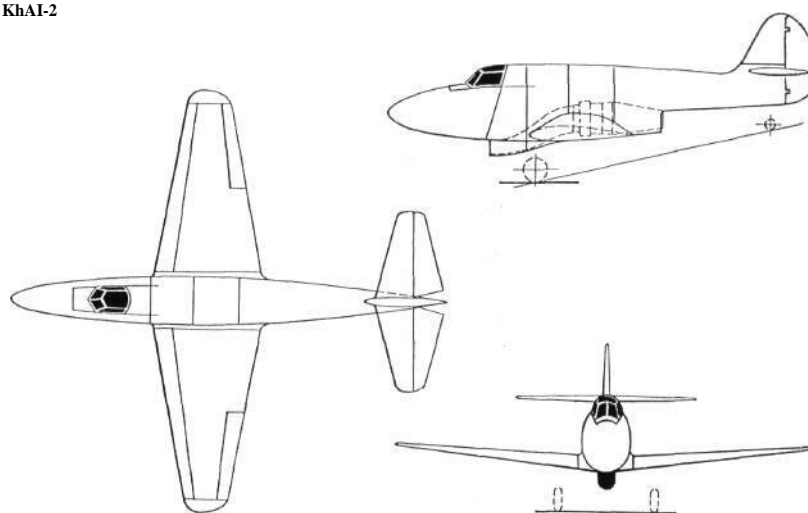
Design Bureau: Arkhip M Lyul'ka and A P Yeremenko, working at Kharkov Aviation Institute.

Dimensions

| | | |
|--------|-------|------------|
| Span | 6.95m | 22 ft 9 in |
| Length | 7.2m | 23 ft 7 in |

This drawing was discovered in 1993. It shows a small aircraft proposed by Yeremenko to test the first turbojet designed by Lyul'ka, who later became one of the Soviet Union's greatest jet engineers. There are two puzzles: the designation KhAI-2 is conspicuously absent from the official history of the KhAI published in 1990; and this designation was in any case used for the Institute's modification of the Po-2 (likewise not mentioned in the book, perhaps because it was not an original Kharkov design). The drawing shows the centrifugal turbojet (which Lyul'ka had not made but calculated to give 525kg [1,157lb] thrust) fed by a ventral inlet, with the nozzle under the rear fuselage. It also suggests that the cockpit could be jettisoned in emergency. Co-author Gunston believes the date must have been rather later than 1936, but this can still claim to have been the world's first design for a jet aircraft.

KhAI-2

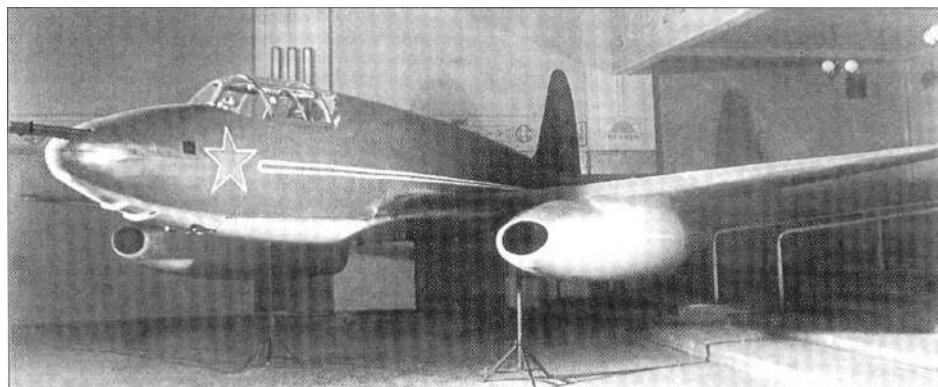


Kostikov 302, Ko-3

Purpose: Simple jet (rocket + ramjet) fighter.

Design Bureau: RNII (reaction-engine scientific research institute) and OKB No 55.

By 1940 the idea of the PVRD (ramjet) was familiar in the Soviet Union, mainly to boost the speed of piston-engined fighters. In 1940 Professor Mikhail Tikhonravov, on the RNII staff, had the better idea of making a simpler and lighter fighter with a ZhRD (liquid-propellant rocket) in the tail and PVRDs under the wings. This could put together various things already developed in the Soviet Union to create what might have been a cheap and quickly produced fighter which, apart from short range and endurance, would have had outstanding performance. Unfortunately, perhaps because it appeared unconventional, this project suffered from endless argument and foot-dragging, finally falling victim to a decision to abandon all such aircraft. According to Shavrov, 'The proposal did not attract any objections from A G Kostikov, Director of the RNII. It was continued as a preliminary project, and approved by the Technical Council of the RNII in spring 1941. It was later examined by a commission of specialists at the WA' (air force academy). This commission, comprising S A Christianovich, A V Chesalov, S N Shishkin, V I Polikovskii and others, proclaimed that This project does not bring out anything new'. Work proceeded at a snail's pace, and Kostikov then took the proposal to the NKAP (state commissariat for aviation industry), where Tikhonravov defended it on 17-18th July 1942. In November 1942 Kostikov showed the proposal to K E Voroshilov, and eventually Stalin himself gave authority for work to resume, appointing Kostikov chief designer. From this time onwards many documents called the project 'Ko-3'. Funding was



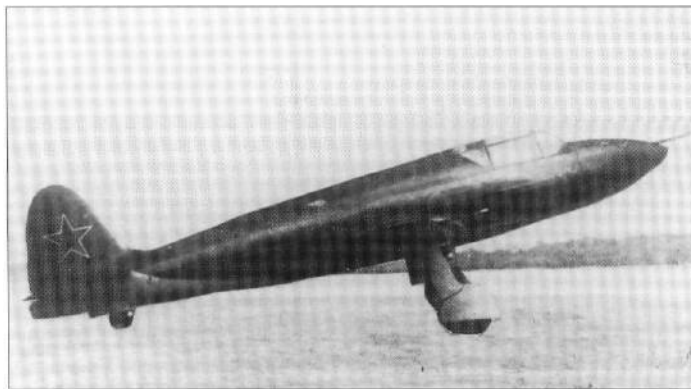
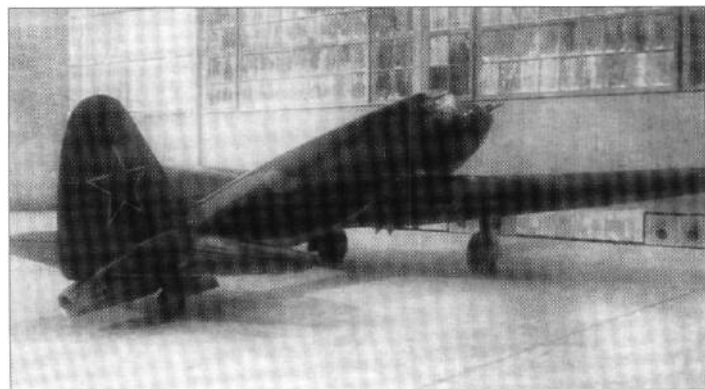
provided for two prototypes, and to build these the RNII set up OKB-55, appointing as director M R Bisnovat (see earlier) and A A Andreyev as his deputy. Tikhonravov did the aerodynamic calculations, while stressing was in the hands of V D Yarovitskii. By spring 1943 two 302 aircraft were almost completed. Testing in the T-104 tunnel at CAHI (TsAGI) began at this time. In 1943 the original proposed ramjets were changed to a new design by Vladimir Stepanovich Zuyev. These were initially tested in a half-scale form, but full-scale testing was never carried out. After much argument it was decided to forget the ramjets and complete the aircraft as the 302P (Perekhvatchik, interceptor) with the rocket only. The PVRD attachments under the wings were faired over, and the wing span reduced. This was flight-tested as a glider at the LII from August 1943, towed to altitude by a North American B-25 and Tu-2. The assigned pilot was initially S N Anokhin, followed by M L Gallai and B N Kudrin, with V N Yelagin as test engineer. The 302P was found to be 'exceptionally good, stable and pleasant to fly', and in March 1944 the second 302P was being tested in the T-104 tunnel at CAHI. In the same month the whole programme was cancelled. A recent Russian magazine article about the 302 omits any mention of Tikhonravov.

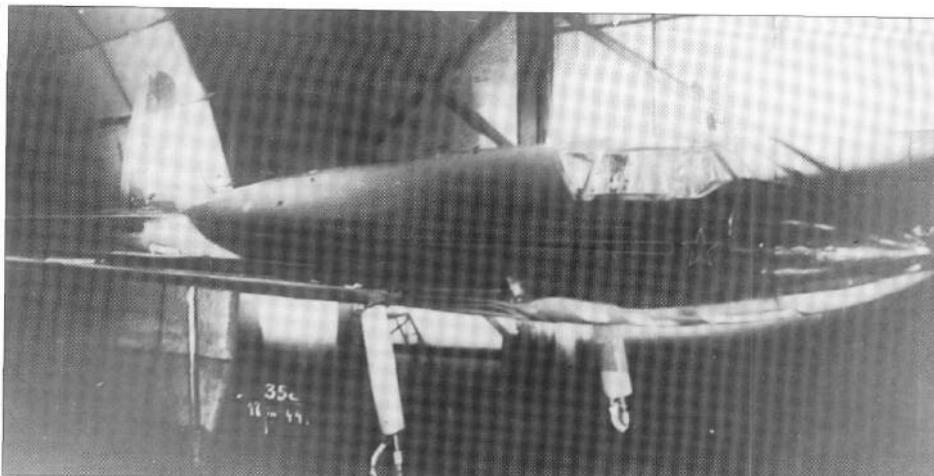
The 302 was made mainly of wood, with a monocoque fuselage and smooth skin of

Delta and Shpon veneers bonded by Bakelite-type plastics. The wings had 15-per-cent RAF.34 profile at the root, tapering to 8-per-cent NACA-230 near the pointed tip. In contrast, the control surfaces were of D1 alloy with fabric covering, the starboard aileron, rudder and both elevators having trim tabs. The rocket engine was a Dushkin/Shtokolov D-1A with a main chamber rated at 1,100kg (2,425lb) at sea level and a cruise chamber rated at 450kg (992lb). Under the wings were to have been installed the ramjets, but information on these Zuyev units is lacking. Their nacelles were to have been oval, with the major axis horizontal, faired neatly into the wing. The all-rocket 302P had tanks for 1,230kg (2,712lb) of RFNA (concentrated nitric acid) and 505kg (1,113lb) of kerosene. The cockpit, which was to have been pressurized, had a canopy hinged to the right and a bulletproof windscreen and frontal armour. The main and tailwheel landing gears were to have been retracted hydraulically, and the same system would have operated the split flaps. No documents have been found describing how the environmental and hydraulic systems would have been energised. Two 20mm ShVAK cannon were to have been mounted in the nose and two more in the bottom of the forward fuselage, each with 100 rounds. In addition, there was to have been provision for underwing racks for RS-82 or RS-132 rockets or two FAB-125 bombs.

Top: 302 with PVRD engines.

Below: Two views of 302.



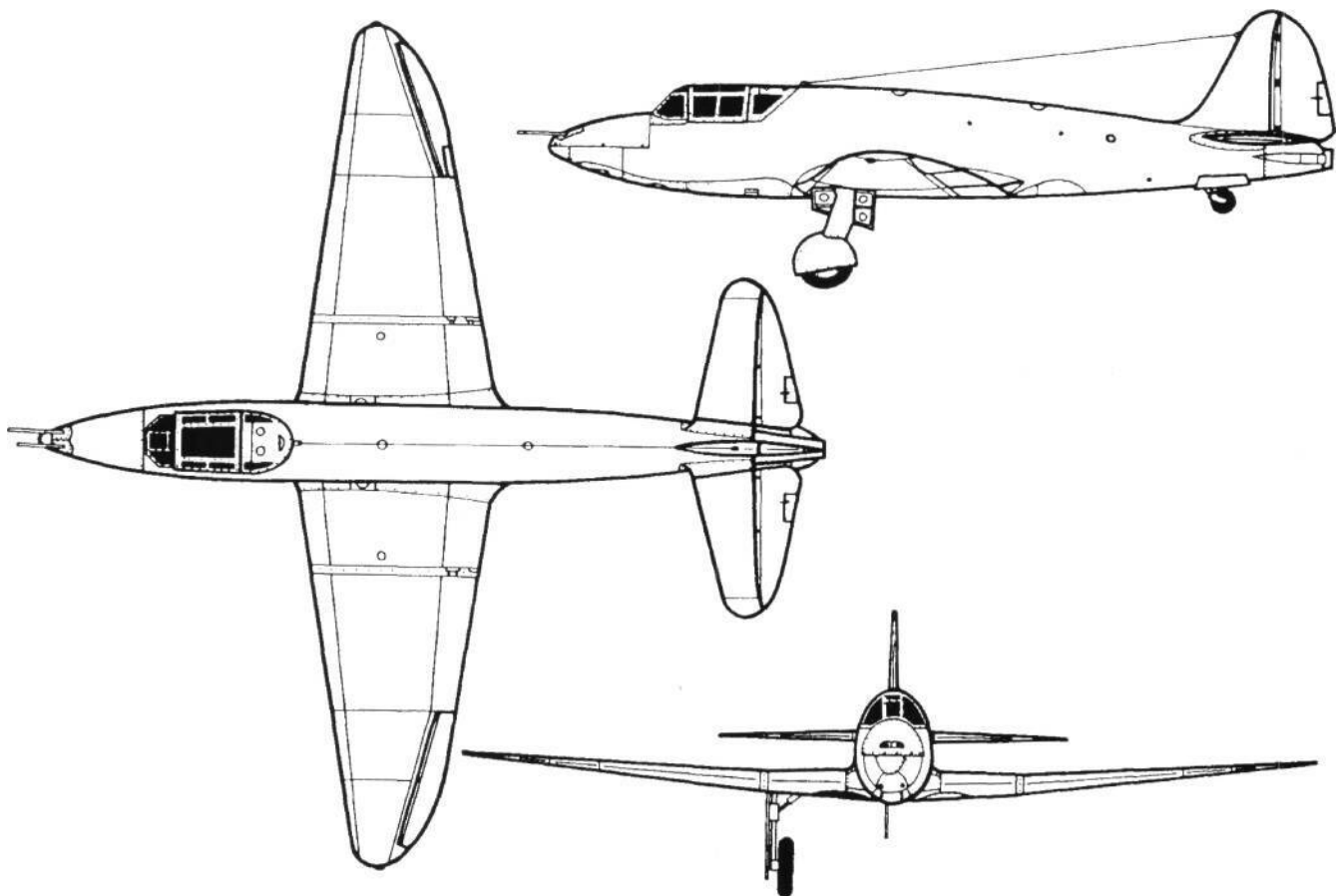


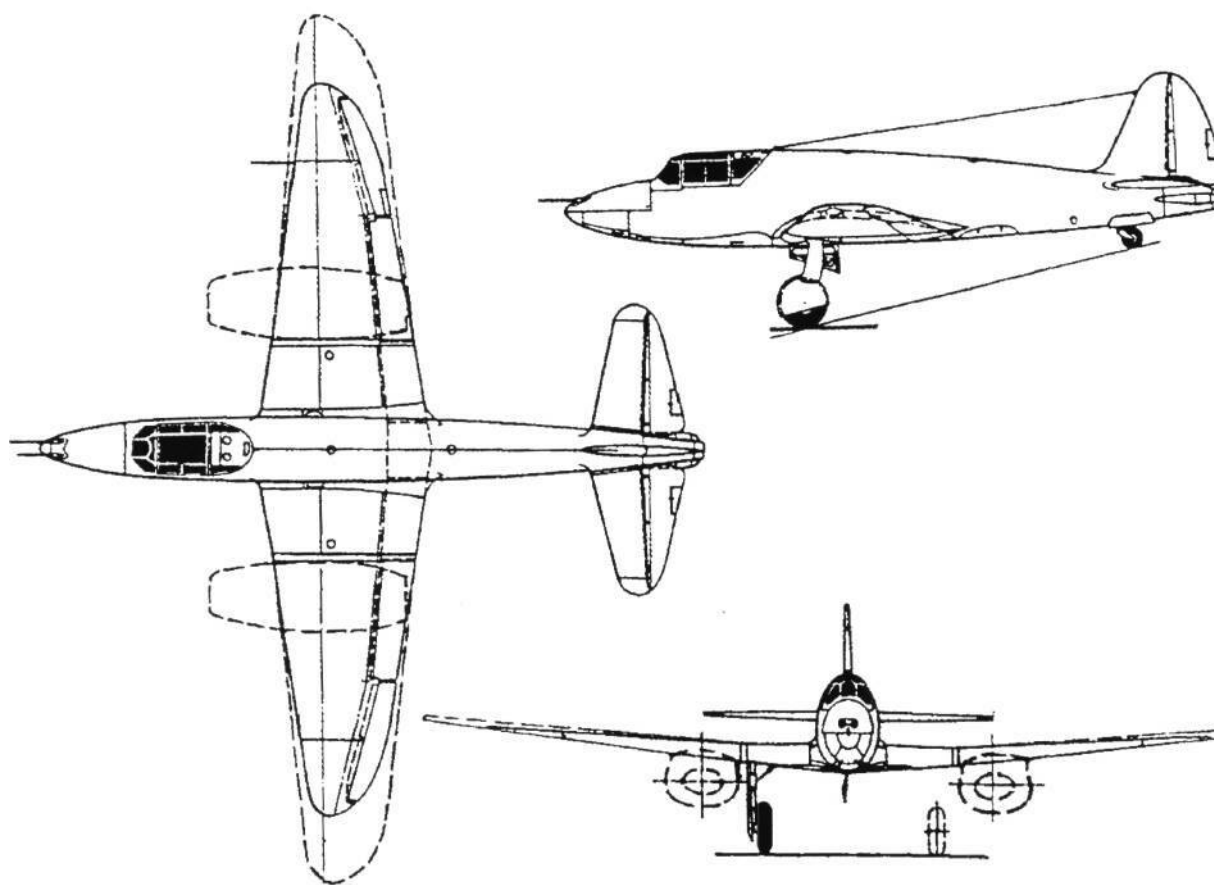
With the benefit of hindsight this appears to have been a considerable case of 'might have been'. Kostikov was a political animal who saw in Tikhonravov's proposal a means to gain advancement and power. Instead, in 1944 a commission headed by A S Yakovlev found him responsible for the failure of the 302 to develop on schedule; he was dismissed from his post and later imprisoned.

302P in CAHI (TsAGI) wind tunnel.

| | | |
|---------------------------------------|--------------------|--------------------|
| Dimensions (302) | | |
| Span (302) | 11.4m | 37 ft Min |
| length (excluding guns) | 8.708m | 28 ft 6 in |
| wing area (302) | 17.8m ² | 192ft ² |
| Weights | | |
| Empty (302) | 1,856kg | 4,092lb |
| Loaded not stated, but about | 3,800 kg | 8,377 lb |
| Performance | | |
| Max speed at sea level, | 800 km/h | 497 mph |
| at altitude | 900 km/h | 559 mph |
| Time to climb to 5 km | 2.1 min | (16,404ft) |
| to 9 km | 2.8 min | (29,528 ft) |
| Service ceiling | 18km | 59,055ft |
| Range | 100km | 62 miles |
| Take-off in 16 seconds at | 200 km/h | 124 mph |
| Dimensions (302P) | | |
| Span | 9.55m | 31 ft 4 in |
| Length (excluding guns) | 8.708m | 28 ft 6 in |
| Wing area | 14.8m ² | 159ft ² |
| Weights | | |
| Empty | 1,502kg | 3,311 lb |
| Loaded | 3,358kg | 7,403lb |
| Performance | | |
| The only measured figure for the 302P | | |
| was a landing speed of | 115 km/h | 71.5 mph |

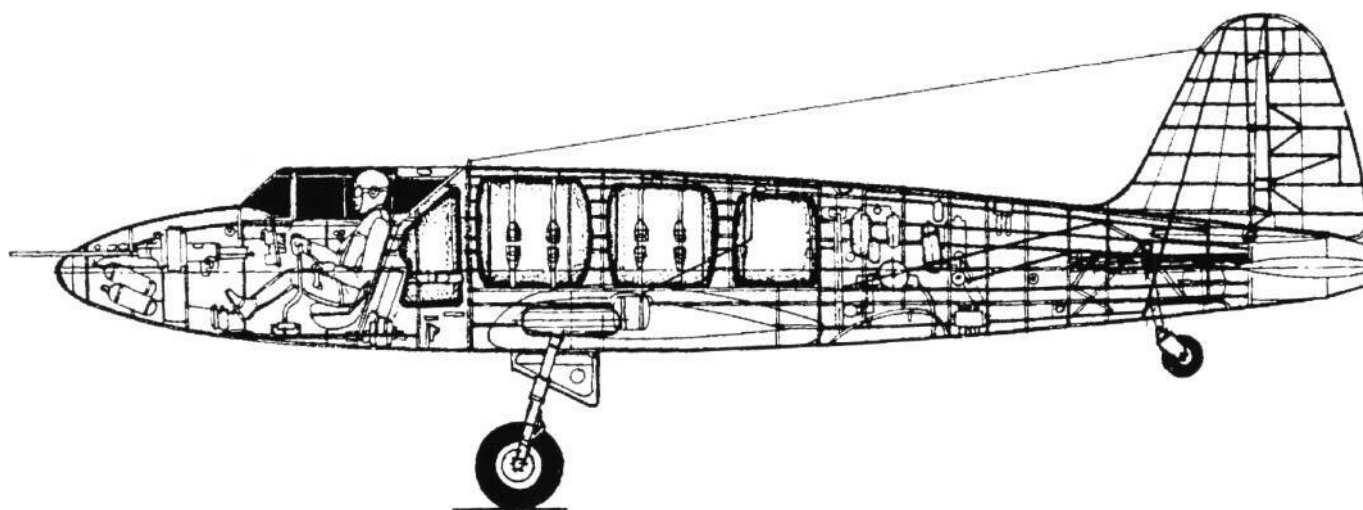
302P





Above: 302 with PVRD engines.

Below: 302P inboard profile.



Korolyov RP-318-1

Purpose: To test a liquid-propellant rocket engine in flight.
Design Bureau: RNII, rocket-engine scientific research institute; head of winged-aircraft department Sergei Pavlovich Korolyov.

Korolyov was a pioneer of light aircraft and, especially, high-performance gliders before, in early 1930s, concentrating on rocketry. In 1934 he schemed the RP-218, a high-altitude rocket aircraft with a two-seat pressure cabin and spatted main landing gear. The engines were eventually to have comprised three RD-1, derived from the ORM-65 (see below), and in a later form the structure was refined and the landing gear made retractable. The RP-218 was never completed, partly because Korolyov was assigned to assist development of the BIC-11 (see under Cheranovskii). In 1935 he produced his SK-9 two-seat glider, and suggested that this could be a useful rocket test-bed. In 1936, in his absence on other projects, A Ya Shcherbakov and A V Pallo began converting this glider as the flight test-bed for the ORM-65. This was fired 20 times on the bench and nine times in Korolyov's RP-212 cruise missile before being installed in the RP-318 and fired on the ground from 16th December 1937. The ORM-65 was

then replaced by the RDA-I-150 No 1, cleared to propel a manned aircraft. This engine was repeatedly tested on the ground, and then flew (without being fired) in four towed flights in October 1939. After further tests the RP-318 was towed off on 28th February 1940 by an R-5 flown by Fikson, with Shcherbakov and Pallo as passengers in the R-5. The SK-9 was released at 2,800m, and then glided down to 2,600m where pilot Vladimir Pavlovich Fedorov fired the rocket. The SK-9 accelerated from 80 to 140km/h on the level and then climbed to 2,900m, the engine stopping after 110 seconds. Fedorov finally landed on a designated spot. Shavrov: This flight was of great significance for Russia's rocket engines'. Much later Korolyov became the architect of the vast Soviet space programme.

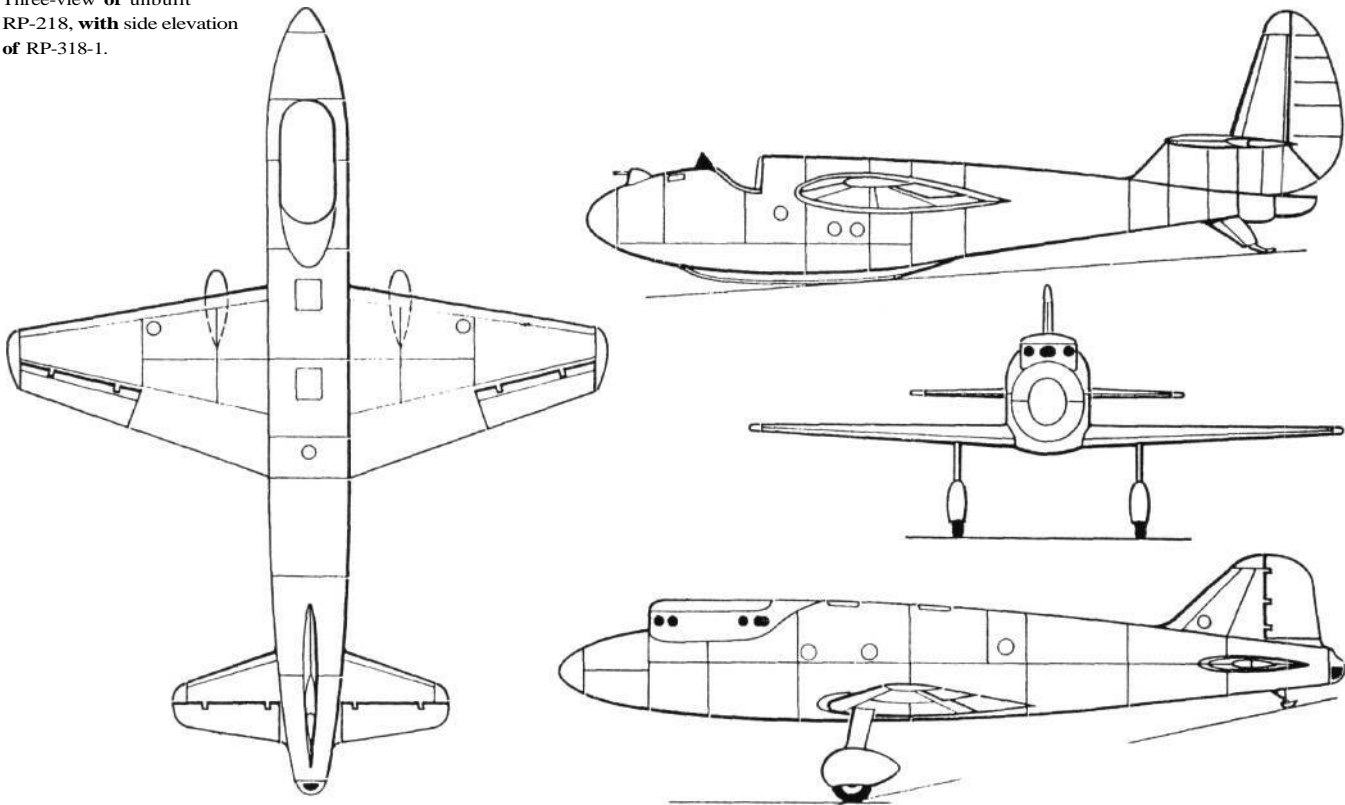
The RP-318-1 was based on the SK-9, a shapely sailplane of mainly wooden construction. The rear seat was replaced by a vertical DI light-alloy tank for 10kg (22 lb) of kerosene, and immediately behind this were two vertical stainless-steel tanks projecting up between the wing spars each holding 20kg (44 lb) of RFNA (red fuming nitric acid). The rocket engine and its pressurized gas feed and complex control system were installed in the rear fuselage, the thrust chamber being

beneath the slightly modified rudder. The RDA-I-150 was a refined version of the ORM-65, designed jointly by V P Glushko and L S Dushkin. Design thrust was 70 to 140kg at sea level, the figure actually achieved being about 100kg (220.5 lb). An additional ski was added under the fuselage.

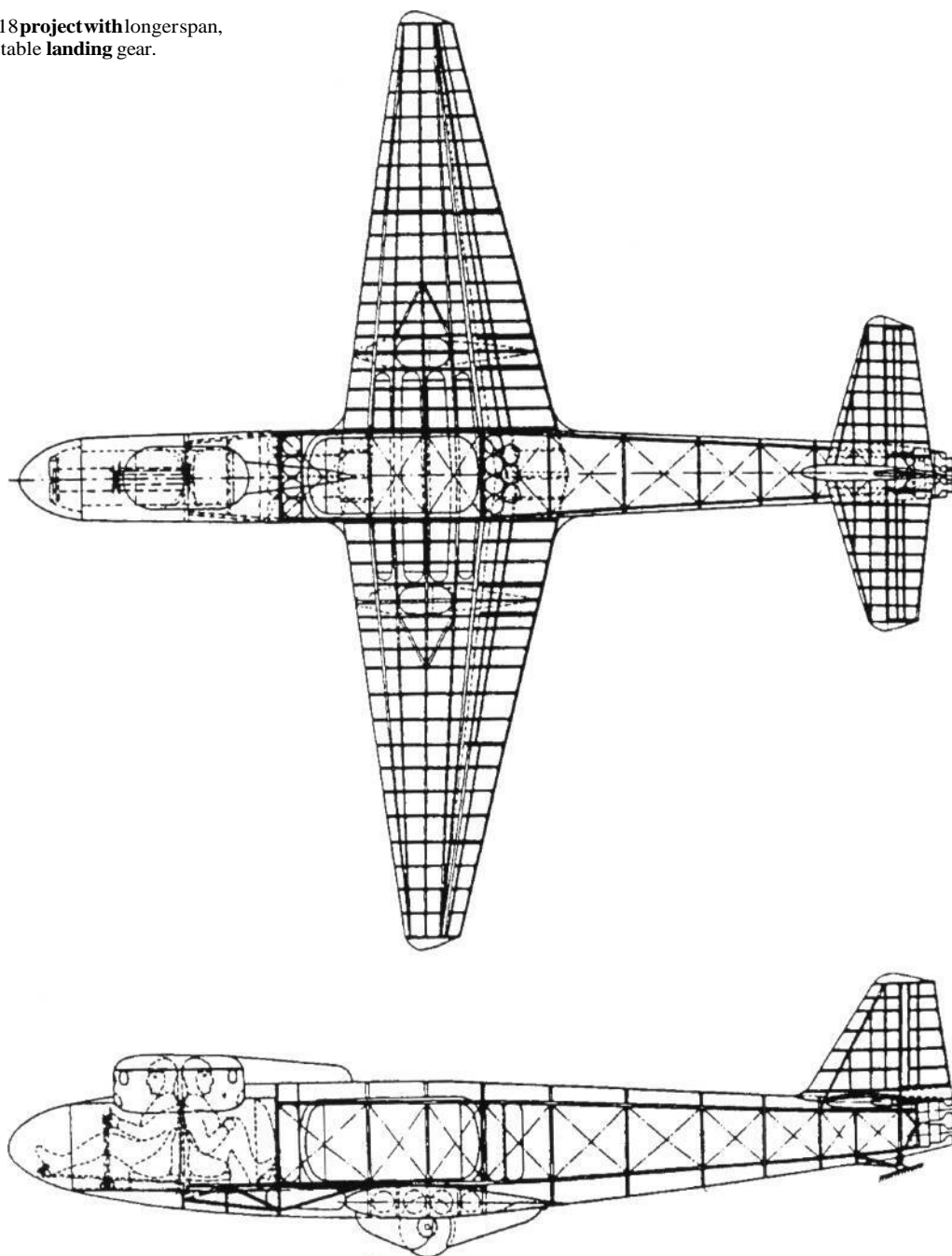
This modest programme appears to have had a major influence on the development of Soviet rocket aircraft.

| | | |
|---------------------------|--------------------|--------------------|
| Dimensions | | |
| Span | 17.0m | 55 ft 9 1/4 in |
| Length | 7.44m | 24 ft 5 in |
| Wing area | 22.0m ² | 237ft ² |
| Weights | | |
| Empty | 570kg | 1,257lb |
| Propellants | 75kg | 165lb |
| Loaded | 700kg | 1,543lb |
| Performance | | |
| Restricted by airframe to | 165km/h | 102.5 mph |

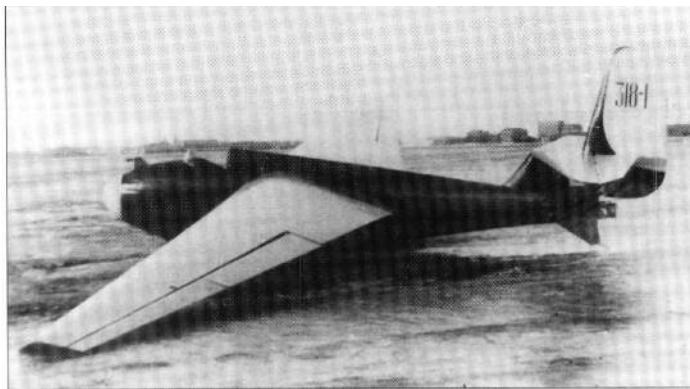
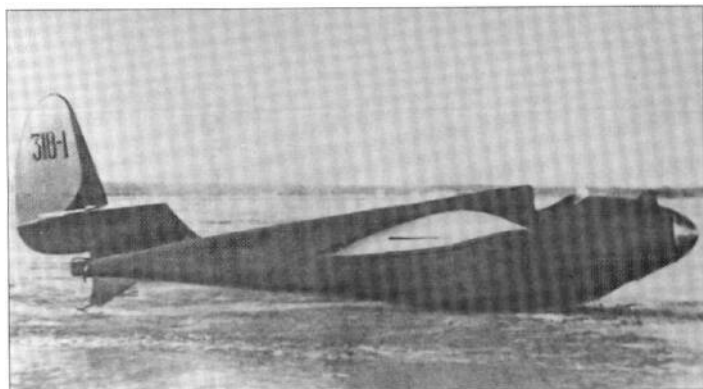
Three-view of unbuilt RP-218, with side elevation of RP-318-1.



Unbuilt later RP-218 **project** with longer span,
new tail **and** retractable landing gear.



Two views of RP-318-1.



Kozlov PS

Purpose: To make an invisible aeroplane.

Design Bureau: Zhukovskii WA, Soviet air force academy; designer Professor Sergei Kozlov.

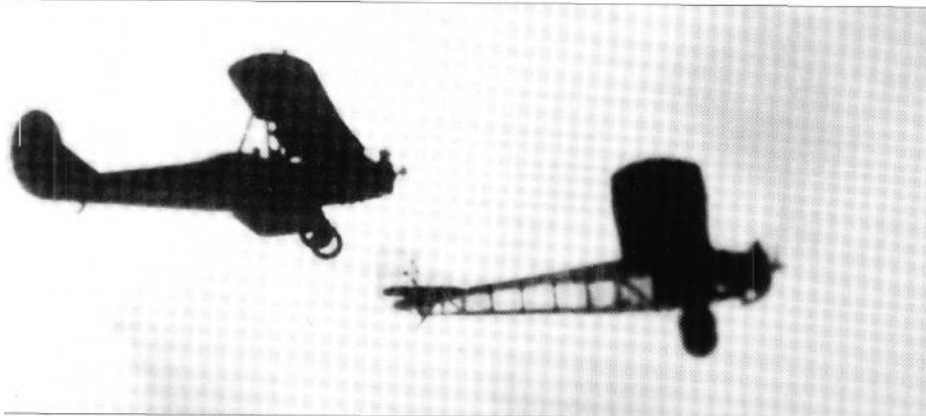
Professor Kozlov was eager to see to what degree it would be possible to construct a 'transparent' aeroplane, difficult to see (for example, by enemies on the ground). In 1933 a preliminary experiment was made with a U-2 biplane whose rear fuselage and tail were stripped of fabric and re-covered with a transparent foil called Cellon (unrelated to the British company of that name). In 1935 the WA was assigned Yakovlev's second AIR-4, which already had experimental status. The airframe was completely stripped of all covering and internal equipment, and reassembled as described below. Though it was called the Nevidimyi Samolyot, invisible aero-

plane, it received the unexplained official designation of **PS**. It first flew on 25th July 1935.

The AIR-4, one of A S Yakovlev's first designs, was a neat parasol monoplane, first flown in 1930. Powered by a 60hp Walter NZ-60 five-cylinder radial, it had two seats in tandem. The structure was almost entirely wood, with skin of ply and fabric. The pairs of wing bracing struts were mild-steel sheet wrapped round to an aerofoil section 64 x 32mm (2 1/2 x 1 1/4 in). Of course, Kozlov could do nothing to hide these struts, nor the rubber-sprung divided main landing gears, or the engine, fuel tank and other parts. Virtually the whole airframe was covered in a French transparent plastic called Rodoid. This was cut from sheet, each panel being drilled and secured by aluminium rivets inserted through eyelets. As far as possible the opaque parts

were painted silver-white.

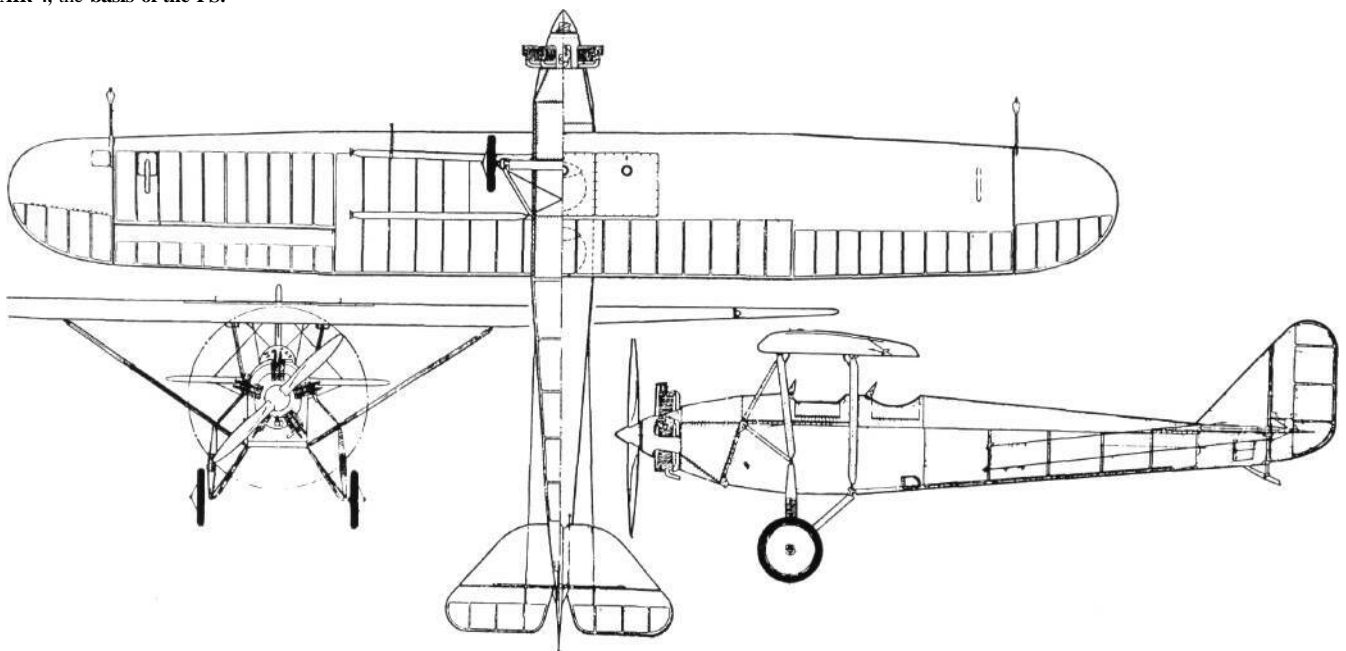
The PS was officially judged to have achieved results which had 'a measure of importance'. Apart from the invisibility effect, the transparent skin was also held to improve the field of view of the occupants, and Kozlov did preliminary studies for a transparent reconnaissance aircraft. On a low-level flypast the **PS** was said to be not easily seen except by chance, though of course observers could narrow the field of search from judging the source of the aircraft's sound. After a few weeks, however, the foil skin was of little use, partly because of progressive darkening by solar radiation and partly because of the effect of dust and oil droplets from the engine.



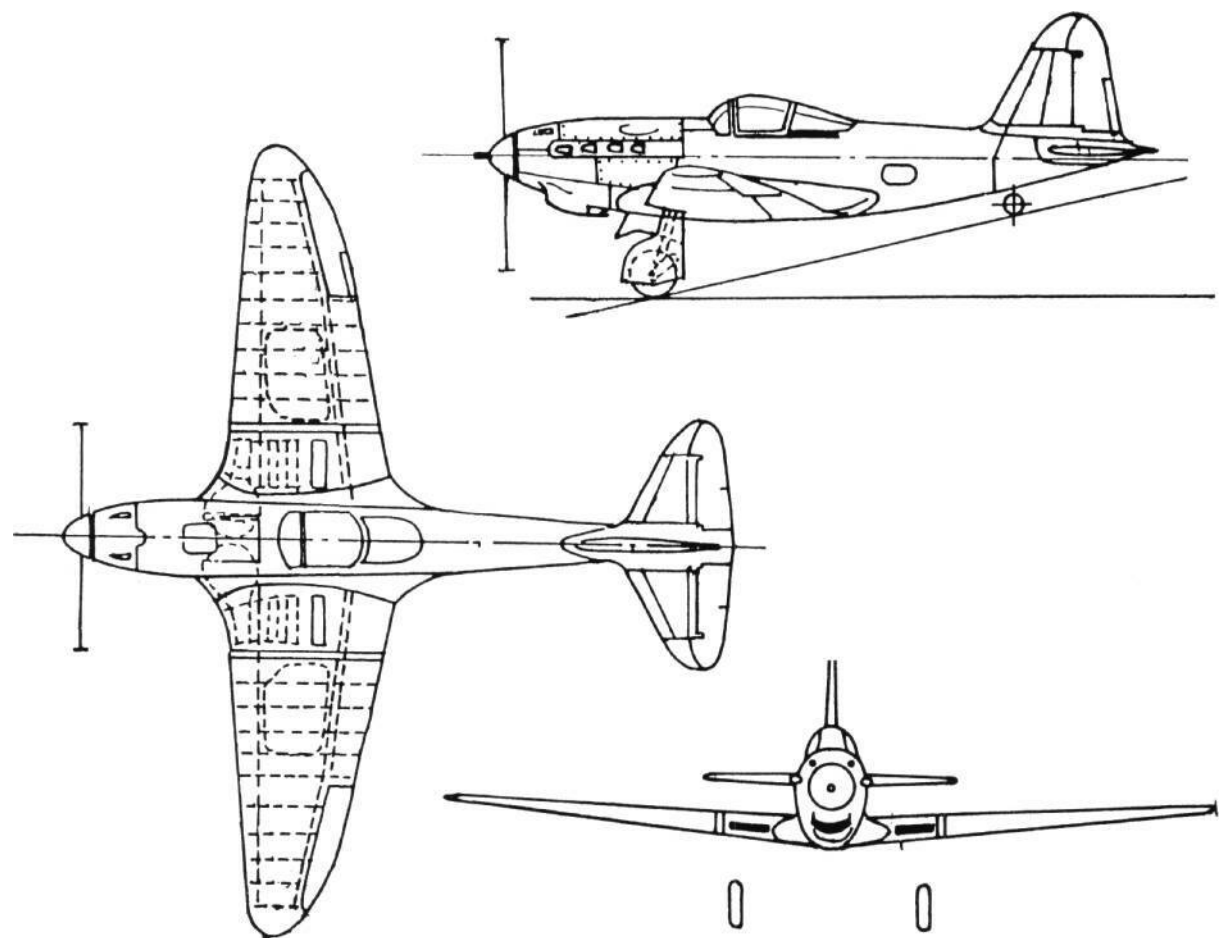
| Dimensions | | |
|--|--------------------|--------------------|
| Span | 11.1m | 36 ft 5 in |
| Length | 6.94 m | 22 ft 9 1/2 in |
| Wing area | 16.5m ² | 178ft ² |
| Weights | | |
| Empty (originally 394 kg) | | |
| as PS probably about | 450 kg | 992 lb |
| Loaded originally | 630 kg | 1,389 lb |
| Performance | | |
| Maximum speed originally | 150 km/h | 93 mph |
| (probably slightly reduced) | | |
| No other helpful data for modified aircraft. | | |

Left: PS accompanied by a U-2.

AIR-4, the basis of the PS.



Kozlov EI



Purpose: To evaluate a fighter with a variable-incidence wing.
Design Bureau: Zhukovskii WA, Soviet air force academy; design team led by ProfessorSG Kozlov.

Kozlov was perpetually seeking after new targets, and one that he had considered for many years was the pivoted wing, able to change its angle of incidence. Thus, for example, the aircraft could take off or land with a large angle of attack yet with the fuselage level. Four Russian designers had made unsuccessful variable-incidence aircraft in 1916-17. Design of the EI (Eksperimentalnyi Istrebitel, experimental fighter) began in 1939. Under Kozlov's direction the wing was designed by V S Chulkov and the landing gear by M M Shishmarev. D O Gurayev was assistant chief designer, and S N Kan and IA Sverdlov handled the stressing. The single EI was constructed at a factory in the Moscow district, but its completion was seriously de-

layed, mainly by technical difficulties and repeated alteration of the drawings. At last the EI was almost complete in autumn 1941, but on 16th October the factory was evacuated. The EI and all drawings were destroyed.
The EI was said to have been a good-looking single-seat fighter, powered by a 1,650hp M-107 (VK-107) liquid-cooled engine. The fuselage was a Duralumin stressed-skin semi-monocoque of oval section, with heavy armament around the engine. The wings had spars with steel T-booms and Duralumin webs, with glued shpon (Birch veneer) skin. The wing was fitted with flaps and differential ailerons, and was mounted on ball-bearing trunnions on the front spar and driven by an irreversible Acme-thread jack acting on the

While no illustration has been found of the EI, this 1940 drawing recently came to light showing a fighter project with a more powerful engine (M-106P) and greater span.

rear spar. To avoid problems it is believed the main landing gears were attached to the fuselage and retracted into fuselage compartments. No other details survive.
There is no reason to believe that the EI would not have met its designer's objectives, but equally it had little chance of being accepted for production. The only successful variable-incidence aircraft was the Vought F8U (F-8) Crusader.

| | | |
|----------------|------|-------------|
| Dimensions | | |
| Span | 9.2m | 30 ft 2K in |
| No other data. | | |

LaGG-3/2 VRD



Purpose: To investigate the use of ramjets to boost fighter performance.

Design Bureau: The OKB of Lavochkin, Gorbunov and Gudkov (LaGG).

Unknown to the outside world, the Soviet Union was the pioneer of ramjet propulsion. Such engines are essentially simple ducts, with air rammed in at the front inlet, slowed in an expanding diffuser, mixed with burning

fuel and expelled at high speed through a rear converging section and nozzle. In 1939 M M Bondaryuk, at NII-GVF OKB-3 (civil air fleet research construction bureau No 3) first ran an experimental subsonic ramjet. In August 1942 a pair of much further developed versions were attached under the wings of LaGG-3 fighter No 31213173 and tested in the air from 5th August. Test pilot Captain Mishenko made 14 flights. Results were indif-

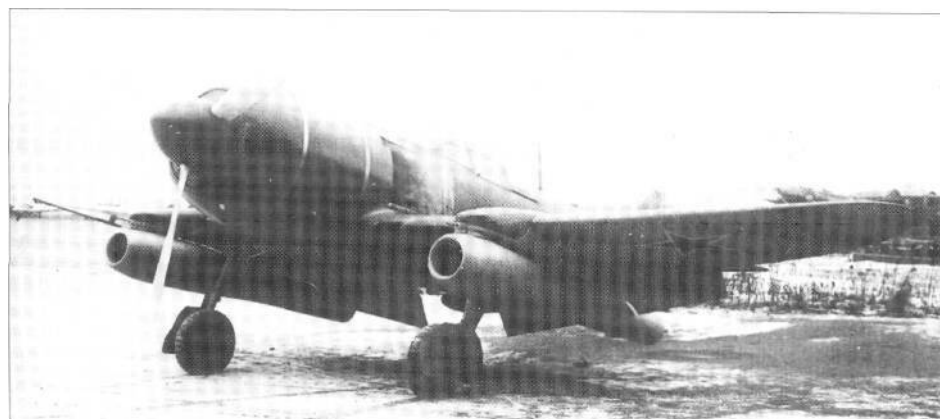
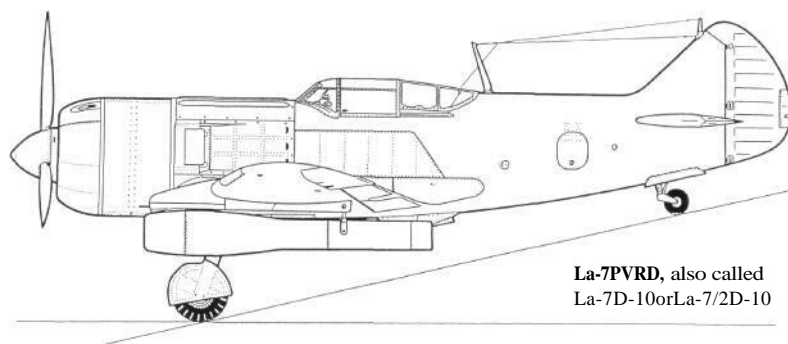
ferent, but provided a background of data for later ramjet work, collated by M V Keldysh.

The LaGG-3 was a mass-produced fighter of all-wood construction, powered by an M-105PF engine. The first Bondaryuk ramjets to fly were designated VRD-1, and were tested in two forms. The original was a plain steel duct with a diameter of 140mm (5 1/2 in), length of 2,150mm (7 ft 1 1/2 in) and weight of 16kg (35.31 lb). The boosted (forsirovannyi) version had a diameter of 170mm (6 3/4 in), but weighed the same. Fuel from the three main aircraft tanks was supplied by a special BNK-10 pump with a proportioner to supply both ramjets equally.

Results were sufficiently interesting to justify further work, starting with the VRD (or PVRD) 430 (see page 89). In parallel Merkulov was developing the DM-4 and similar ramjets, tested on the I-153 and I-207.

| Dimensions | | |
|--------------------------------------|----------------------|-----------------------|
| Span | 9.81 m | 32 ft 2 in |
| Length | 8.82 m | 28 ft 7 in |
| Wing area | 17.62 m ² | 189.7 ft ² |
| Weight and performance not recorded. | | |

Lavochkin La-7PVRD and La-9RD



Purpose: To investigate the use of pulsejets to boost fighter performance.

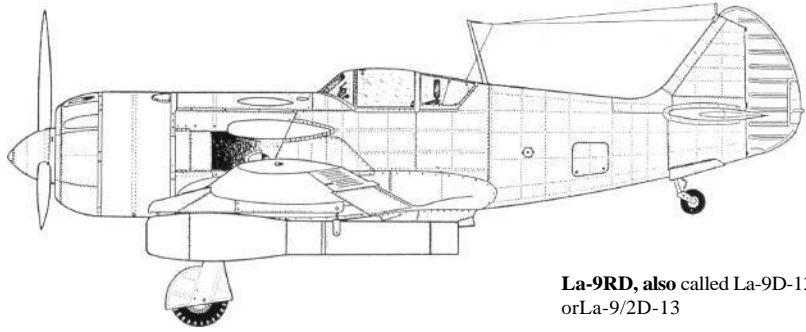
Design Bureau: The OKB of Semyon A Lavochkin.

In 1942 Vladimir N Chelomey, working at TsIAM (Central Institute of Aviation Motors) began bench-testing the first pulsejet in the Soviet Union. This was independent of work by the German Argus company, which because of Soviet secrecy became famed as the pioneer of such engines. The Soviet unit received two designations, D-10 and RD-13. In 1946 the first two flight-cleared D-10 engines were hung under the wings of a slightly modified La-7, which was designated La-7PVRD. In the second half of 1947 a second pair, designated RD-13, were flown under the wings of an La-9, which misleadingly received the designation La-9RD. Despite the fact that the programme had already been abandoned, eight further La-9 fighters were fitted with these engines, and all nine made a deafening formation flypast at the Tushino Aviation Day.

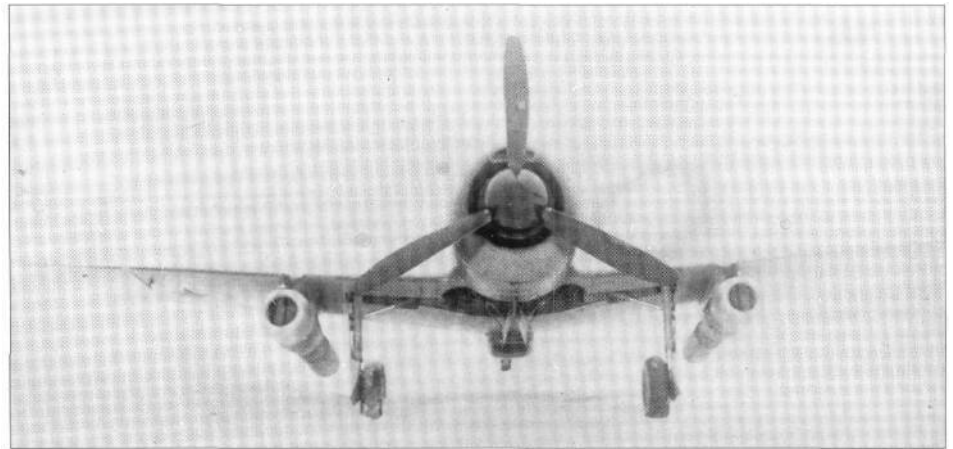
Left: La-7/2D-10.

The D-10 pulsejet appears to have been heavier than the German 109-014 unit of similar size, though weight data are lacking. The duct was mainly aluminium at the front and steel to the rear of the fuel injectors. Fuel was drawn from the main aircraft tanks and ignition was electrical. The unit was suspended from a shallow pylon projecting ahead of the wing leading edge with two main attachments, with a steadying attachment at the rear. Apart from the pulsejet instrumentation and control system a few modifications were needed to the aircraft, the main one being to remove a large portion of flap above the pulsejet jetpipe. No data are available describing how thrust varied with airspeed or height; Shavrov merely gives the thrust of a single D-10 as 200kg (44lb).

Though these pulsejets performed as expected, they significantly added to aircraft weight and drag, and reduced manoeuvrability, especially rate of roll. In addition, the violent vibration transmitted to the aircraft 'made flying difficult' and was very unpopular with pilots.



La-9RD, also called La-9D-13 or La-9/2D-13



Dimensions (La-7PVRD)

| | | |
|-----------|---------------------|--------------------|
| Span | 9.8m | 32 ft 10 in |
| Length | 8.6m | 28 ft 3 in |
| Wing area | 17.59m ² | 189ft ² |

Weights

| | | |
|--------|----------|----------|
| Empty | 2,998kg | 6,609 lb |
| Loaded | 3,701 kg | 8,159 lb |

Performance

Maximum speed, according to Shavrov the calculated speeds were 800 km/h at 6,000 m and 715 km/h at 8,000 m, whereas the actual speeds at these heights were 670 km/h (416 mph) and 620 km/h (385 mph), or marginally lower than without the pulsejets!

Dimensions (La-9RD)

| | | |
|-----------|---------------------|---------------------|
| Span | 9.8m | 32ftP/U n |
| Length | 8.63m | 28 ft 3% in |
| Wing area | 17.72m ² | 191 ft ² |

Weights

| | | |
|--------|---------|----------|
| Empty | 3,150kg | 6,944 lb |
| Loaded | 3,815kg | 8,410 lb |

Performance

Maximum speed, the calculated gain was 127 km/h, but Shavrov gives the actual achieved speed as 674 km/h (419 mph), 16 km/h slower than the original La-9.

Right: Three views of La-9RD.

Lavochkin La 7R and '120R'

Purpose: To use a rocket engine to boost a fighter's flight performance.

Design Bureau: OKB of Semyon A Lavochkin.

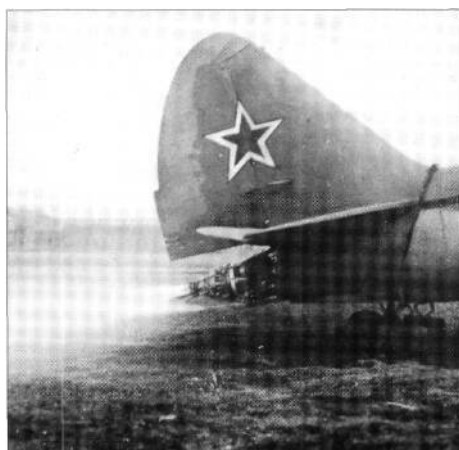
By early 1944 the all-wood La-5 fighter had given way in production to the La-7, with metal spars and other modifications. The engine remained the ASh-82FN 14-cylinder radial rated at 1,600hp. One of the first production aircraft was fitted with an RD-1 rocket engine in order to boost its performance, especially at extreme altitudes where the ASh-82 family of engines were less impressive. The installation was completed in the late autumn of 1944, and ground testing occupied nine weeks. In the last week of the year the assigned pilot, Georgii M Shiyonov, began the flight-test programme. Together with AV Davydov the La-7R was flown 15 times without serious malfunction, though the pro-

gramme had to be abandoned because of progressive weakening of the rear fuselage by vapour and accidental spillage of the acid. Testing was continued with the RD-1KhZ installed in a second La-7R in early 1945. Brief testing was also carried out with a similar engine installed in the '120R'. On 18th August 1946 this aircraft excited spectators at the Aviation Day at Tushino by making a low flypast with the rocket in operation.

Both the La-7R test aircraft were originally standard production fighters. The RD-1 was one of the world's first liquid-propellant rocket engines to fly in a manned aircraft, the designer being V P Glushko. The thrust chamber was mounted on a framework of welded steel tubes carried behind a modified rear fuselage frame, which merged at the top into the fin trailing edge. To accommodate the rocket the lower part of the rudder was removed. In the fuselage behind the cockpit were a stainless-steel tank for 180 litres (39.6 Imperial gallons) of RFNA (concentrated red fuming nitric acid) and 90 litres (19.8 Imperial gallons) of kerosene. These propellants were supplied by a turbopump energised by hot gas bled from the main thrust chamber. The turbine had a governed speed of 26,000rpm, and drove pumps for the two propellants plus lubricating oil and water supplied from a small tank to cool the turbine and thrust chamber walls. Mass of the installation was approximately 100kg (220 lb), or 215kg (474 lb) complete with propellants and water. The basic RD-1 had electrical ignition, while the RD-1KhZ had automatic chemical ignition from hypergolic liquids. The rocket was of the on/off type, cut in or out by a switch on the main throttle lever. It could not be varied in thrust (300kg, 661 lb, at sea level), but could be shut off before the tanks were empty, nor-

mal duration being 3 to 31/2min. Both La-7R aircraft retained their armament of two UB-20 cannon. The '120R' differed in having an ASh-83 engine, rated at 1,900hp, armament of two NS-23 guns and in other details.

Together with such other aircraft as the Pe-2RD and Yak-3RD these test-beds confirmed the value of a rocket engine in boosting performance at high altitude. On the other hand they also confirmed that RFNA is not compatible with a wooden structure, and in any case the value of three minutes of boost was considered questionable.



Above: Ground test of '120R' rocket engine.

Opposite: Two views of La-7R.

| | | |
|----------------------|---------------------|--------------------|
| Dimensions (both) | | |
| Span | 9.8m | 32 ft IK in |
| Length | 8.6m | 28 ft TM |
| Wing area | 17.59m ² | 189ft ² |
| Weights (La-7R) | | |
| Empty | 2,703kg. | 5,959lb |
| Fuel and propellants | 604kg | 1,332lb |
| Loaded | 3,500kg | 7,716lb |

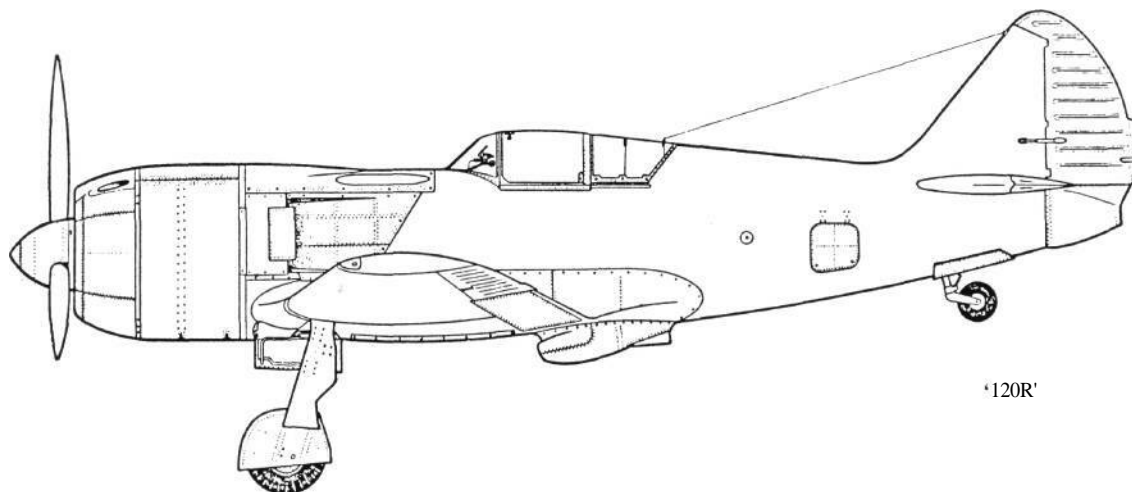
| | | |
|--|---------|---------|
| Weights ('120R') | | |
| Empty | 2,770kg | 6,107lb |
| Fuel and propellants | 470kg | 1,036lb |
| Loaded | 3,470kg | 7,650lb |
| A standard La-7 typically had empty and loaded weights of 2,600kg and 3,260 kg | | |

Performance

(La-7R) generally unchanged, but maximum speed at 6 km (19,685 ft) altitude was increased from 680 km/h (422.5 mph) to 752 km/h (467 mph).

Service ceiling was increased from 10,700 m (35,105 ft) to 13,000 m (42,651 ft).

The only figure recorded for the '120R' is a speed (height unstated) of 725 km/h (450.5 mph), but this speed (at 7,400 m) is also recorded for the unboosted '120'.



'120R'



Lavochkin '164' (La-126PVRD) and '138' (130PVRD-430)

Purpose: To test the use of ramjets to boost propulsion of a fighter.

Design Bureau: The OKB of S A Lavochkin.

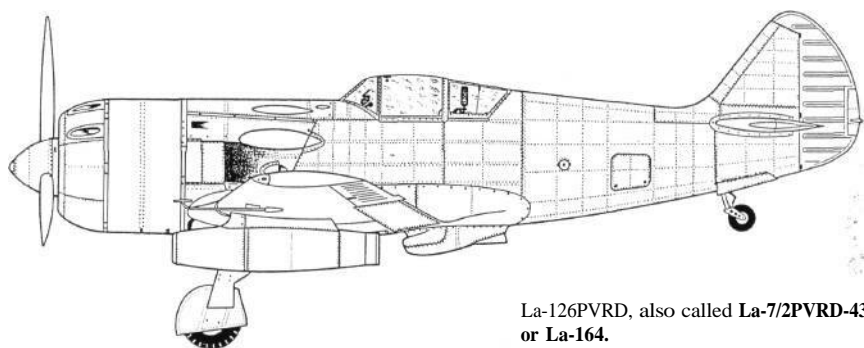
By 1942 M M Bondaryuk had achieved reliable operation with the VRD-430. By this time this refined subsonic ramjet had flown over 200 times on test-bed aircraft. In early 1946 two were attached under the wings of '126', a slightly modified La-7, to produce the La-126PVRD, given the OKB number '164'. The assigned pilot was A V Davidov, and he tested this aircraft between June and September 1946.

The VRD-430 was a simple ramjet designed for subsonic operation. It was made mainly of steel, and had a diameter of 400mm (1ft 3 3/8 in).

Able to burn almost any thin hydrocarbon fuel, including high-octane petrol (gasoline), it had a thrust in the region of 300kg (661 lb), but performance data for this engine have not been found, neither have details of its fuel and control system. The La-126 was based on the La-7 but had a completely metal stressed-skin airframe, a new wing of so-called laminar profile, a modified canopy and many other changes, including the devastating armament of four NS-23 guns firing projectiles with more than twice the mass of the 20mm ShVAK. The La-138 was basically an La-9 fighter, in which the new wing and armament of the La-126 were matched with a completely redesigned fuselage. As before, a VRD-430 ramjet was hung under each wing,

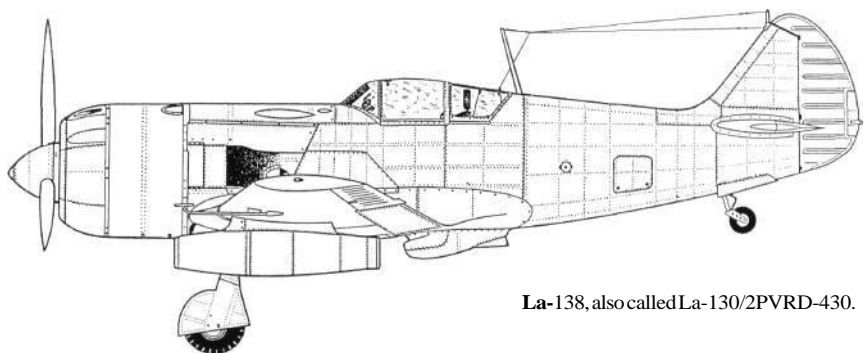
to produce the '164'. The '138' was the designation of the '130' after it had been fitted with two VRD-430 ramjets. It emerged in this form at the end of 1946, and flight tested 20 times between March and August 1947. Very few details survive regarding this aircraft, possibly because in the turbojet era it did not appear to be important.

The VRD-430 demonstrated its ability to boost speed (see below) but at the expense of high fuel consumption and a serious increase in drag when the ramjets were not being used. It is not clear why the La-126PVRD speed was 'boosted by 64km/h' by the ramjets, while the corresponding figure for the La-138 was almost twice as great.



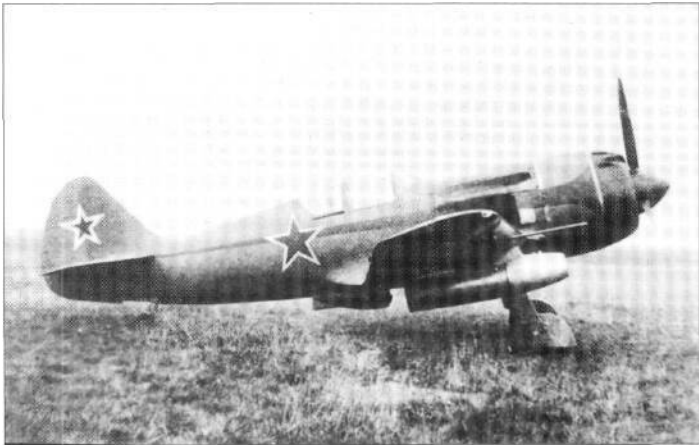
La-126PVRD, also called **La-7/2PVRD-430** or **La-164**.

| | | |
|---------------------------------|---------------------|----------------------|
| Dimensions (164) | | |
| Span | 9.8m | 32 ft 1% in |
| Length | 8.64m | 28 ft 4 1/2 in |
| Wing area | 17.59m ² | 189.3ft ² |
| Weights | | |
| Empty | 2,710kg | 5,974lb |
| Loaded | 3,275kg | 7,220lb |
| Performance | | |
| Max speed at 2,340 m (7,678 ft) | 694 km/h | 431 mph |
| Range with brief VRD usage | 730 km | 454 miles |
| Landing speed | 145.6 km/h | 90.5 mph |
| /run | 688 m | 2,257 ft |



La-138, also called **La-130/2PVRD-430**.

| | | |
|---|---------------------|----------------------|
| Dimensions (138) | | |
| Span | 9.8m | 32 ft 1% in |
| Length | 8.625 m | 28 ft 3 1/2 in |
| Wing area | 17.59m ² | 189.3ft ² |
| Weights | | |
| Empty | 3,104kg | 6,843 lb |
| Loaded | 3,730kg | 8,223 lb |
| Performance | | |
| Max speed at 6,000 m (19,685 ft) | 760 km/h | 472 mph |
| which does not quite equate with the contemporary claim of 'boosted by 107-1 12 km/h' | | |
| Range with brief VRD usage | 1,100km | 683.5 miles |
| Take-off run | 450m | 1,476ft |
| Landing speed | 139 km/h | 86.4 mph |

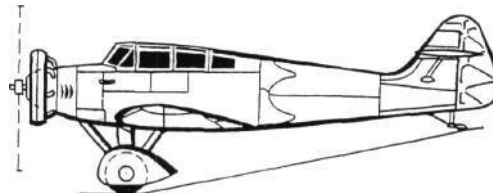
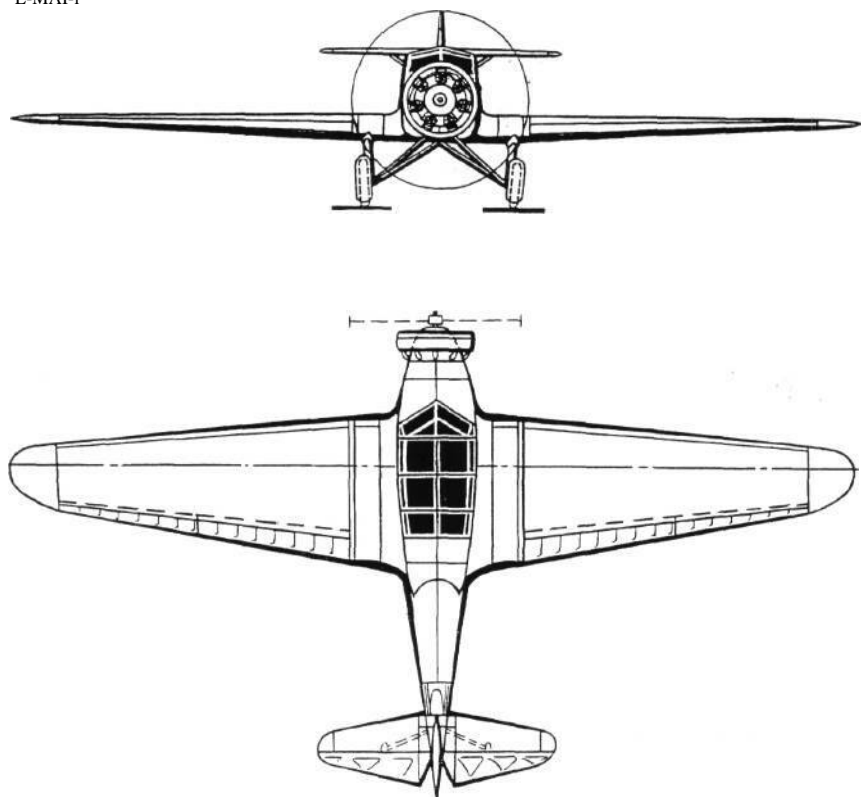


Top left and right, bottom left: Three views of **La-126PVRD**

Bottom right: **La-138**.

MAI EMAI-1

E-MAI-1



Dimensions

| | | |
|-----------|---------------------|---------------------|
| Span | 12.0m | 39 ft 4 1/4 in |
| Length | 7.03m | 23 ft 1/4 in |
| Wing area | 20.0 m ² | 215 ft ² |

Weights

| | | |
|--------------|---------|----------|
| Empty | 700kg | 1,543 lb |
| Fuel and oil | 165kg | 364 lb |
| Loaded | 1,200kg | 2,646 lb |

Performance

| | | |
|---------------|----------|-----------|
| Maximum speed | 227 km/h | 141 mph |
| Range | 800km | 497 miles |
| Landing speed | 75 km/h | 46.6 mph |

Purpose: To see whether a safe aeroplane could be constructed from magnesium.

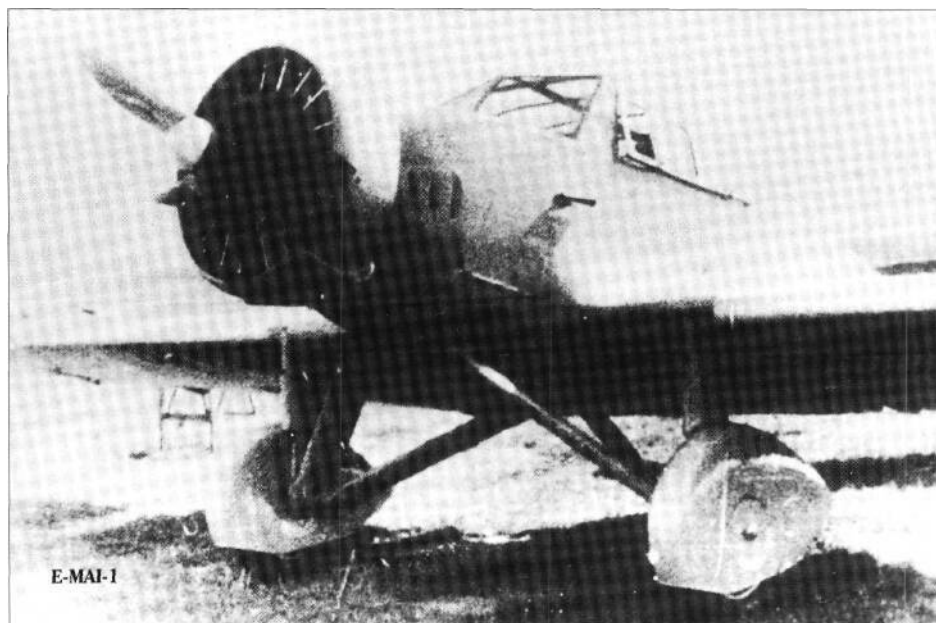
Design Bureau: Moscow Aviation Institute.

As magnesium has a density of 1.74, compared with 2.7 for aluminium and almost 8 for typical steels, it seemed reasonable to the MAI management to investigate its use as a primary structural material. In 1932 such a project was authorised by Director A M Belenkovich and the GUAP (civil aviation ministry), and a year later a design team was assembled under Professors S I Zonshain and A L Gimmelfarb, with construction led by N F Chekhonin. A neat four-seat low-wing monoplane was quickly designed, and flown about 600 times in 1934-39. It was also statically tested at (CAHI) TsAGI.

The EMAI was also known as the E-MAI, Elektron MAI, EMAI-1, E-1, EMAI-I-34 and Sergo Ordzhonikidze. Elektron is the name of the alloy with Al, Mn and Zn, considerably stronger than pure Mg, which was used for most of the airframe. The straight-tapered wings were based on Steiger's Monospar principles, with the ribs and single spar built up from square and tubular sections. The entire trailing edge was hinged, forming ailerons and plain flaps. The well-profiled fuselage was largely skinned in Elektron, the wings and tail being covered in fabric. On the nose

was the Salmson seven-cylinder radial engine, rated at 175hp, in a ring cowl and driving a two-blade propeller. The strut-braced tailplane was mounted high on the fin, and the rubber-sprung main landing gears had spats. The cockpit was covered by one sliding and one hinged canopy. Most of the structure was welded, but many joints were bolted so that they could be dismantled.

The EMAI-1 was judged to be a complete success, with a structure weight '42 per cent lower than using aluminium, steel tube or wood'. The fire risk was not considered a serious hazard, and according to MAI the main reason for not taking the use of Elektron further was because in the USSR there was not enough spare electric power available to produce the magnesium.



MAI-62 and MAI-63

Purpose: To investigate light flying-wing aircraft.

Design Bureau: Moscow Aviation Institute.

In 1958 the academic faculty of the Institute decided to carry out a major investigation into LK (Letayushcheye Krylo, flying wing) aircraft. The programme began with the LK-MAI glider and the MAI-59 ultralight, but these remained on the drawing board. Extensive tunnel testing of models led to a configuration with a broad diamond or lozenge-shaped centre section and swept outer panels which at their tips turned back (sweepback 90°) to terminate in surfaces doubling as airbrakes and as elevons. The MAI-62 was designed and built in 1961-62, but it was not flown until in 1965 AI Pietsukh attempted a take-off. Dur-

ing the long run the engine seriously overheated and ran intermittently, and the take-off was abandoned. The MAI-63 glider followed in 1963, first flown in 1964 by AI Pietsukh. In 1965 an engine was fitted, to produce the MAI-63M, but again the engine proved 'unsteady' and the aircraft never flew in this form.

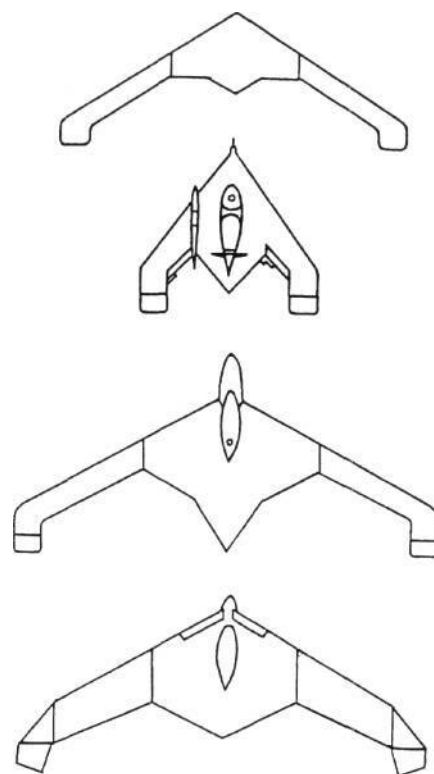
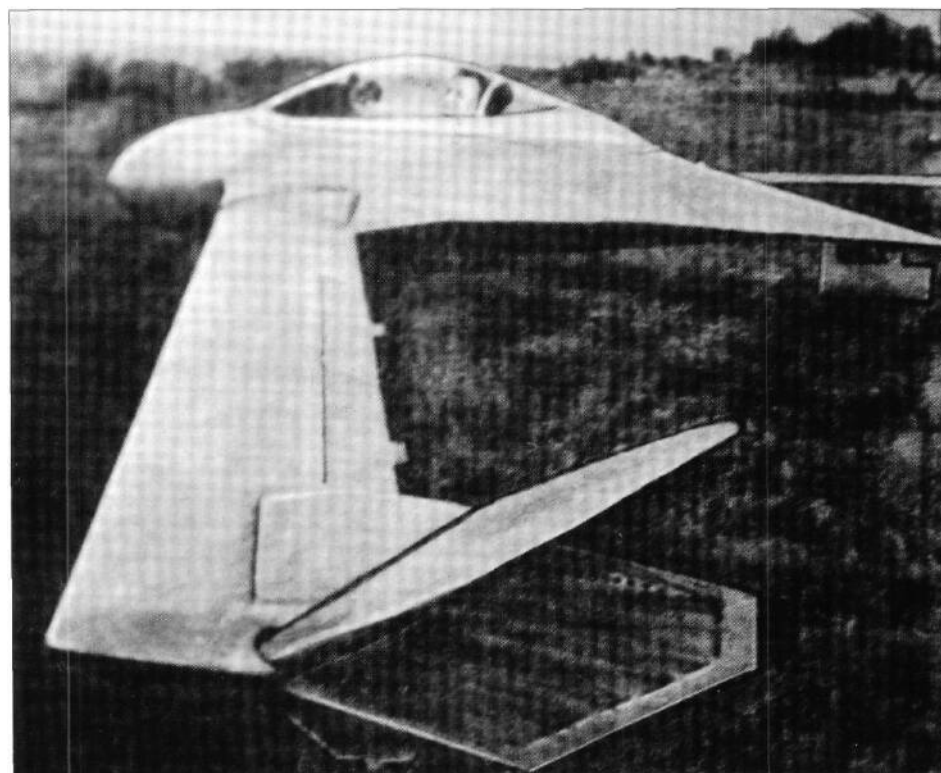
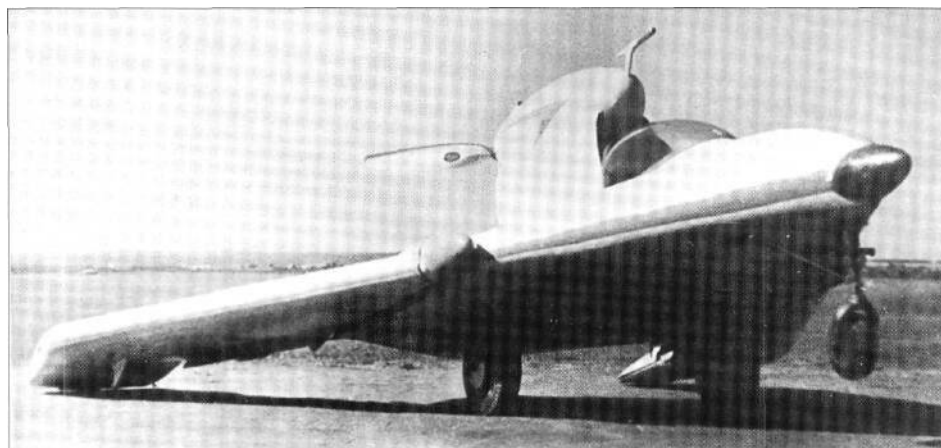
Both the MAI-62 and MAI-63 were made almost entirely of wood, with birch ply veneer covering. Both had a single-seat cockpit with a sideways-hinged canopy, cable-operated wingtip elevons which could split into upper and lower halves to act as airbrakes, and fixed nosewheel landing gear. The MAI-62 was powered by a Khirt air-cooled engine of 80hp driving a two-blade pusher propeller. The years 1962-65 were spent tinkering with

the details of the wings, which had a leading-edge sweep of 45° (shown in drawings as 50°), adding or subtracting various fences, inboard flaps, trim tabs and servo tabs. Released photographs carefully avoided showing these surfaces. The MAI-63 had a much greater span, with leading-edge sweep reduced to 25°, and two different forms of split tip airbrakes supplemented by constant-chord hinged trailing edges to the main wing. The engine of the MAI-63M was a VP-760, rated at 23hp.

One is left wondering whether the failure of these aircraft to fly was really due to the engine or to doubts about their controllability.

Below left: MAI-62.

Bottom: MAI-63.



Development of the MAI 'LK' series

Dimensions MAI-62

| | | |
|---------------------------|--------------------|---------------------|
| Span | 5.0 m | 16ft4.5in |
| length | 5.0 m | 16 ft 4 3/4 in |
| wing area | 6.0 m ² | 64.6ft ² |
| Weight empty | 250 kg | 551 lb |
| loaded | 380 kg | 838 lb |
| Performance not measured. | | |

Dimensions MAI-63M

| | | |
|---|--------------------|----------------------|
| Span | 12.6m | 41 ft 4 in |
| length not recorded; | | |
| wing area | 9.0 m ² | 96.9 ft ² |
| Weight and performance data not recorded. | | |

Mikhel'sonMP

Purpose: To build a faster torpedo-carrying aircraft.

Design Bureau: Factory No 3 Krasnyi Lyotchik 'Red Flyer', Leningrad, see below.

The designation MP derived from Morskoi Podvesnoi, naval suspended. The reasoning began with the belief that to attack a heavily defended ship called for a small and agile aircraft with high performance, but that such an aircraft could not have a long range. Accordingly engineer N Val'ko suggested carrying the attack aircraft under a large long-range aeroplane in the manner pioneered by Vakhmistrov. In 1936 this concept was accepted by the VMF (war air fleet) and assigned to N G Mikhel'son in partnership with AI Morshchikhin, with assistance from Vakhmistrov. The design was completed by VVNikitin (see page 145). According to Shavrov 'During prototype construction numerous problems arose, and since half could not be solved it was decided to discontinue development'. In fact, by 1938 the MP was ready for flight, but the political atmosphere (the Terror) was so frightening that nobody dared to sanction the start of flight testing in case anything went wrong. The MP was accordingly given to the Pioneers' Palace.

The MP was superficially arranged like a fighter, with an 860hp Hispano-Suiza 12Ybrs engine driving a three-blade propeller and cooled by a radiator in the top of the fuselage behind the cockpit. The airframe was made almost entirely from duralumin, though the basis of the fuselage was a truss of welded Cr-Mo steel tube. The cockpit was enclosed and featured the then-fashionable forward-sloping windscreen. Flight-control surfaces were covered in fabric. The 45-36-AN, a full-size 553mm torpedo, was carried in a large recess under the fuselage. For ground manoeuvring the aircraft had wheeled main landing gear and a tailskid. The main gears retracted upwards, the shock struts travelling outwards along tracks in the wing. The loaded MP was to be hoisted under a TB-3 carrier aircraft and carried close to the target, such as an enemy fleet. The engine would then be started and the aircraft released, with the TB-3 in a dive to increase speed at release. The MP would then aim its torpedo and fly back to its coastal base. Before landing, the pilot would engage a mechanism which would raise the engine 20° upwards. The MP could then alight on the water and taxi to its mooring. The water landing was facilitated by the high position of the horizontal tail and the

location of the engine radiator on top of the rear fuselage. The unladen aircraft was designed to float with the wings just resting on the water (see front view drawing), the wings serving as stabilizing sponsons.

There is no reason to doubt that this scheme might have proved practicable. One of the drawings shows in side elevation a proposed faster next-generation aircraft developed from the MP.

Dimensions

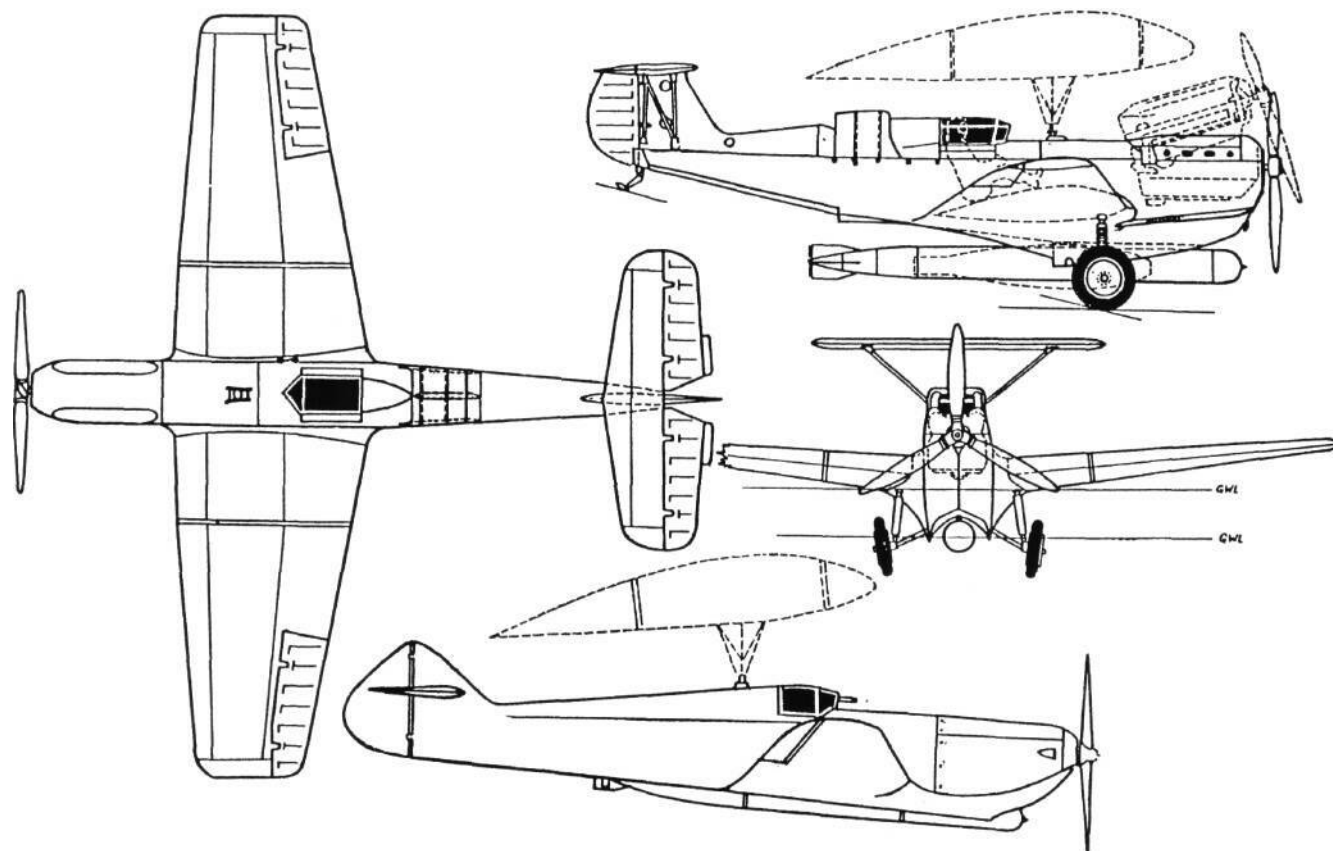
| | | |
|--------------|--------------------|--------------------|
| Span | 8.5m | 27 ft 10 in |
| Length about | 8.0m | 26 ft 3 in |
| Wing area | 20.0m ² | 215ft ² |

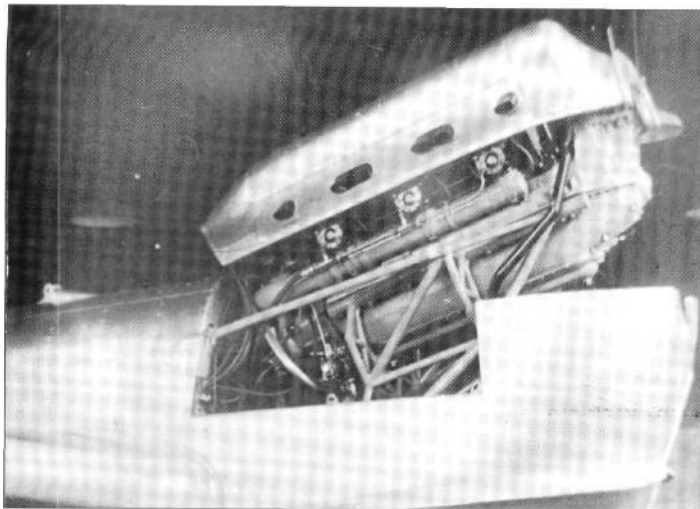
| | | |
|-------------|----------|----------|
| Weights | | |
| Empty about | 2,200 kg | 4,850 lb |
| Loaded | 3,200 kg | 7,055 lb |

Performance not recorded.

MP, with additional side view of projected high-speed development.

Mikhel'son MP





Above and right: Details of engine and radiator (both marked 'secret').

MiG-8 Utka

Purpose: To create a safe and easily flown light aeroplane.

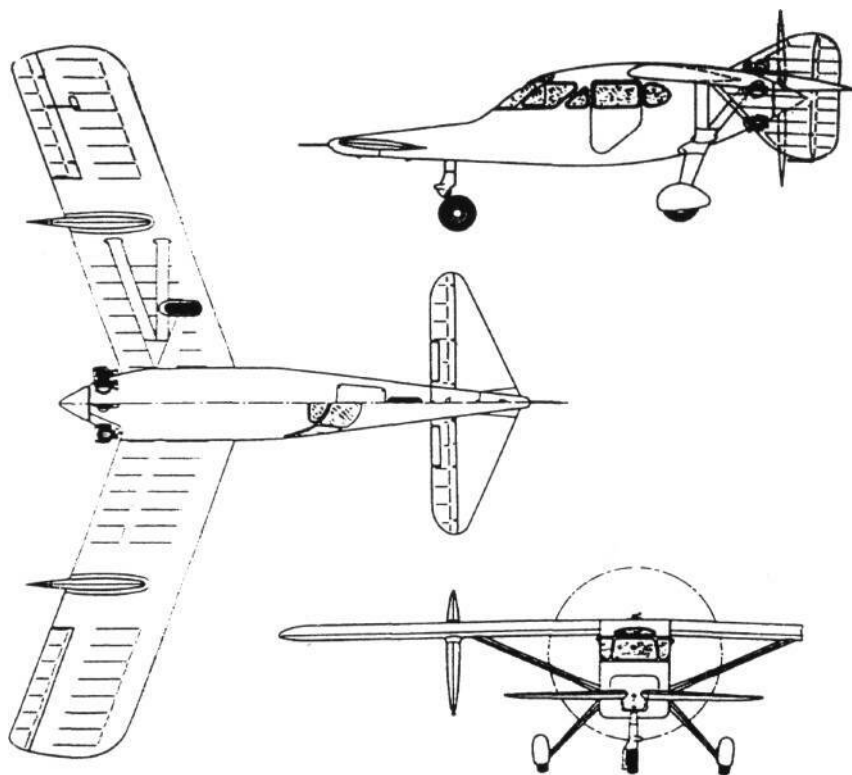
Design Bureau: OKB-155 of AI Mikoyan.

Previously famous for a succession of high-performance fighters, the MiG bureau began to relax as the Great Patriotic War ended. Without any requirement from GUAP, Aeroflot or anywhere else, its principals decided to investigate the design of a light air-

craft with an M-11 engine which could replace the Po-2 (originally designated U-2) as a machine which could be safely flown by any pilot from almost any field. The project was assigned to students at the WA (air force academy) under Col (later Professor) G A Tokayev. The OKB kept a close watch on the design, and soon judged that its slightly swept wing could be useful in assisting the design of future jet fighters. The main elements of the design were settled by July 1945, and thereafter construction was rapid. The aircraft was named Utka (duck) because of its canard configuration. Aleksandr Ivanovich Zhukov made the first flight on 19th November 1945. The wingtip fins and rudders proved unsatisfactory, and for the next six months the MiG-8 was modified repeatedly, as explained below. Its flight testing was handled by OKB pilot Aleksei Nikolayevich Grinchik, assisted by I Ivashchenko and other pilots of the LII MAP (Ministry Flight Research Institute). By the summer of 1946 the MiG-8 was considered more or less perfect. No explanation is available for the fact that this aircraft never went into production as the Po-2 replacement. The MiG-8 was used for many years as the OKB's communications aircraft, and also as a test-bed for various kinds of research.

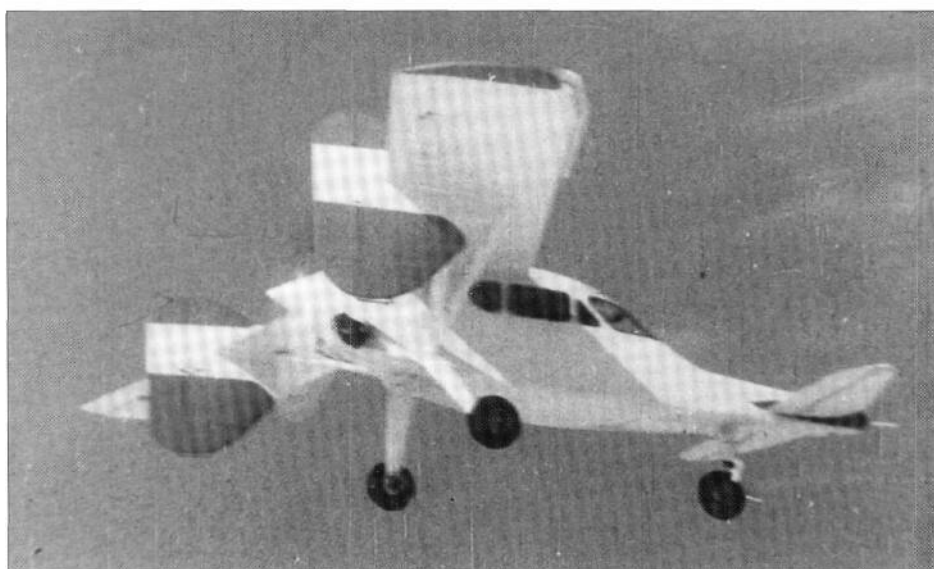
The MiG-8 was a small cabin aircraft distinguished by a pusher engine at the tail, a canard foreplane and a high-mounted wing at the rear. Construction was of wood, mainly pine, with ply skin over the fuselage, wing leading edge and fixed foreplane. The wing had Clark Y-H section, with a thickness/chord ratio of 12 per cent. In plan the wings were untapered but swept back at 20°, with V-struts to

MiG-8 original configuration.



the bottom of the fuselage. The fuselage comprised a cabin with a door on each side, tapering at the rear around the M-11F radial engine rated at HOhp, driving a 2.36m (7ft 9in) two-blade wooden propeller. A total of 195 litres (43 Imperial gallons) of fuel was housed in aluminium tanks in each wing. At the front of the cabin a Po-2 instrument panel was installed for the pilot, and two passenger seats were added behind, with a small space for luggage behind them. Ahead of the cabin a slender nose was added to carry the delta foreplane, fixed at 3° incidence. This was fitted with fabric-covered elevators provided with trim tabs, with movement of $\pm 25^\circ$. Total foreplane area was 2.7m² (29ft²). On the outer wings were fabric-covered ailerons, ahead of which were large fixed slats on the leading edge. On the wing tips were delta-shaped fins carrying one-piece rudders, with a total combined area of 3m² (32.3ft²). All control surfaces were operated by rods and bellcranks. The landing gear comprised a levered-suspension nose unit with a 300x150mm tyre, and spatted mainwheels with 500 x 150mm tyres and pneumatic brakes on cantilever legs pivoted to the strut attachment bulkhead, with bungee shock absorbers in the fuselage. Provision was made for skis, but no photographs show these fitted. The first flight showed that directional stability was poor. The wing was given 1° anhedral, and the fins and rudders were moved in to 55 per cent of the semi-span and mounted vertically, with a mass balance projecting ahead from the bottom of each rudder. The spats were removed, and a new nose gear was fitted with the same wheel/tyre as the main units. Later the wing anhedral was increased to 2°. Considerable attention was paid to engine cooling, and eventually the projecting cylinders were fitted with individual helmets, though no photographs have been found showing this (they were eventually removed except over the two bottom cylinders). In its final form the MiG-8 had a single fuel tank between the firewall and engine. An important further modification was to remove the slats, and photographs also show that in the final configuration the wingtips were angled downwards. At one time the entire aircraft was covered with tufts to indicate the airflow. In its final form the MiG-8 was nice to fly, and recovery from a spin was achieved merely by releasing the flight controls.

Despite its unusual configuration the MiG-8 was eventually developed into an excellent aircraft, safe to fly and easily maintained, though at the end of the day it was judged that future jet fighters should not have a canard configuration. No explanation has been given for the fact that the MiG-8 never led to production utility, ambulance or photographic aircraft.



| | | |
|------------|--------------------|----------------------|
| Dimensions | | |
| Span | 9.5m | 31 ft 2 in |
| length | 6.995 m | 22 ft 11 in |
| wing area | 15.0m ² | 161.5ft ² |

| | | |
|------------------|------------|-----------|
| Weights | | |
| Empty (as built) | 652kg | 1,437lb |
| (later) | 642kg | 1,415 lb |
| Fuel/oil | 140+ 14 kg | 309+31 lb |
| Loaded | 1,150kg | 2,535 lb |

| | | |
|----------------------------|---------|-----------|
| Performance | | |
| Maximum speed at sea level | | |
| (as built) | 205km/h | 127 mph |
| (later) | 210km/h | 130.5 mph |
| Range | 500 km | 311 miles |
| Take-off run | 238 m | 781ft |
| Landing speed | 77 km/h | 48 mph |

Top left: MiG-8 original configuration.

Top right: On ground with spats.

Centre: In flight with slats open.

Above: Fully tufted to show airflow.

MiG I-250, MiG-13, N

Purpose: To boost the speed of a piston-engined fighter.

Design Bureau: The OKB-155 of AI Mikoyan.

In 1942 the Central Institute for Aviation Motors (often abbreviated as TsIAM) began to develop an unusual method of boosting the propulsive power of fighter aircraft. Called VRDK (from Russian for 'air reaction auxiliary compressor') it involved adding a drive from the main engine to an auxiliary compressor for a flow of air rammed in at a forward-facing inlet. The compressed air was then expelled through a combustion chamber and propulsive nozzle. This scheme was worked on by a team led by V Kh Kholshchevnikov. In January 1944 the governments of the UK and USA announced their possession of jet aircraft. In a near-panic response, the GKO (State Committee for Defence) ordered all the main Soviet fighter OKBs to build jet aircraft. Stalin criticised designers for not already having such aircraft. As the only Soviet turbojet (the Lyul'ka VRD-2) was nowhere near ready for use, MiG and Sukhoi were assigned the urgent task of creating prototype fighters to use the VRDK booster system. Both quickly came to the conclusion that the VRDK method could not readily be applied to any of their existing fighters, and both designed special (quite small) fighters to investigate it. The MiG aircraft was called N by the OKB, and given the official designation I-250. The project was assigned to G Ye Lozino-Lozinskii. A mock-up was approved on 26th October 1944, and after frantic effort the 'N' No1 was rolled out painted white on 26th February 1945. OKB pilot A P Dyeyev began the flight-test programme on 3rd March. Soon the magic 800km/h mark was exceeded, and Mikoyan presented Dyeyev with a car. VRDK operation was generally satisfactory but deafeningly noisy. On 19th May a tailplane failed at low level and the 'N' No1 crashed. By this time 'N' No2 was almost ready to fly. Painted dark blue, with a yellow nose and horizontal streak, it was restricted to 800km/h to avoid a repetition of the failure. Stalin had meanwhile ordered that a 'regiment' of ten of these aircraft should fly over Red Square on 7th November, October Revolution Day. 'N' No2 was tested by LII pilot A P Yakimov, assisted by OKB pilot A N Chernoburov. This aircraft was written off in a forced landing in 1946. The hastily built ten further I-250s were tested by IT Ivashchenko. On 7th November nine were ready, but the flypast was cancelled because of bad weather. In late 1946 Factory No 381 was given an order for 16 fully equipped fighter versions, designated MiG-13. Factory testing of these took place in May-

July 1947, 1 M Sukhomlin carried out Nil-WS testing between 9th October 1947 and 8th April 1948, and these aircraft were then delivered to the AV-MF. They served with the Baltic and Northern Fleets until 1950.

Aircraft N bore little similarity to any previous MiG design. Made entirely of metal, with a stressed-skin covering, it was smaller than most fighters, whereas its predecessors had been larger. The straight-tapered wing had a CAHI 10%-thick laminar aerofoil, with two spars and plate ribs. Movable surfaces comprised two-part Frise ailerons and hydraulically operated CAHI slotted flaps. The fuselage was relatively deep to accommodate the unique propulsion system. The engine was a VK-107, rated at 1,650hp for take-off and 1,450hp at 3,500m (12,470ft). At the front it was geared down to drive the AV-5B three-blade constant-speed propeller of 3.1m (10ft 2in) diameter. At the back it drove the engine's own internal supercharger as well as a clutch which, when engaged, drove through 13:21 step-up gears to a single-stage axial compressor. This pumped air through a large duct from a nose inlet. Just behind the compressor was the engine's cooling radiator. Behind this were seven nozzles from which, when the auxiliary compressor was engaged, fuel from the main tanks was sprayed and ignited by sparking plugs. The resulting flame filled the large combustion chamber, from which a high-velocity jet escaped through a two-position nozzle. Downstream of the burners the entire duct was refractory steel, and when the VRDK was in operation its walls were cooled by water sprayed from a 78 litre (17 Imperial gallon) tank, the steam adding to the thrust. At 7,000m (22,966ft) the VRDK was estimated to add 1,350hp, to a total of 2,500hp. The oil cooler surrounded the propeller gearbox, with flow controlled by gills round the top of the nose. The engine was mounted on a steel-tube truss. Fuel was housed in three self-sealing tanks, one of 415 litres (91.3 Imperial gallons) in the fuselage and one of 100 litres (22.0 Imperial gallons) in each wing. The large central tank forced the cockpit to be near the tail, with a sliding canopy. The metal-skinned tail was repeatedly modified, the small elevators having a tab on the left side. A unique feature of the main landing gear was that the wheels were carried on single levered-suspension arms projecting forward from the leg. The tail-wheel was fully retractable. Even the first aircraft, called 'N' No1, was fully armed with three B-20 cannon, each with 160 rounds. The MiG-13 batch differed in having a larger vertical tail, larger fuel and water tanks, RSI-4 radio with a wire antenna from the fin to a

mast projecting forwards from the wind-screen, and (temporarily) strange curved propeller blades in an attempt to reduce tip Mach number.

These aircraft performed as expected, but were a dead-end attempt to wring the last bit of performance from piston-engined fighters.

| | | |
|--------------------------|--------------------|---------------------|
| Dimensions (I-250) | | |
| Span | 9.5m | 31 ft 2 in |
| Length | 8.185m | 26 ft 10 in |
| Wing area | 15.0m ² | 161 ft ² |
| Weights | | |
| Empty | 2,935kg | 6,470.5 lb |
| Fuel/oil/water | 450/80/75 kg | 992/176/165 lb |
| Loaded | 3,680 kg | 8,113 lb |
| Performance | | |
| Max speed at sea level | 620km/h | 385 mph |
| at 7,000 m (22,966 ft) | 825 km/h | 513 mph |
| Time to climb to 5,000 m | 3.9 min | (16,404ft) |
| Service ceiling | 11,960m | 39,240ft |
| (without VRDK) | 10,500m | 34,450 ft |
| Range (with brief VRDK) | 920km | 572 miles |
| (no VRDK) | 1,380km | 858 miles |
| Take-off speed/ | 200 km/h | 124 mph |
| run | 400m | 1,312ft |
| Landing speed/ | 150 km/h | 93 mph |
| run | 515m | 1,690ft |
| Dimensions (MiG-13) | | |
| Span | 9.5m | 31 ft 2 in |
| Length | 8.185m | 26 ft 10 in |
| Wing area | 15.0m ² | 161 ft ² |
| Weights | | |
| Empty | 3,028kg | 6,675 lb |
| Fuel/oil/water | 590/80/78 kg | 1,301/176/172 lb |
| Loaded | 3,931 kg | 8,666 lb |
| Performance | | |
| Max speed at sea level | 620 km/h | 385 mph |
| at 7,000m (22,966 ft) | 825 km/h | 513 mph |
| Time to climb to 5,000 m | 3.9 min | (16,404ft) |
| Service ceiling | 11,960m | 39,240ft |
| without VRDK | 10,500m | 34,450ft |
| Range (with brief VRDK) | 1,818km | 1,130 miles |
| (no VRDK) | 1,380km | 858 miles |
| Take-off speed/ | 200 km/h | 124 mph |
| run | 400m | 1,312ft |
| Landing speed/ | 195 km/h | 121 mph |
| run | 515m | 1,690ft |

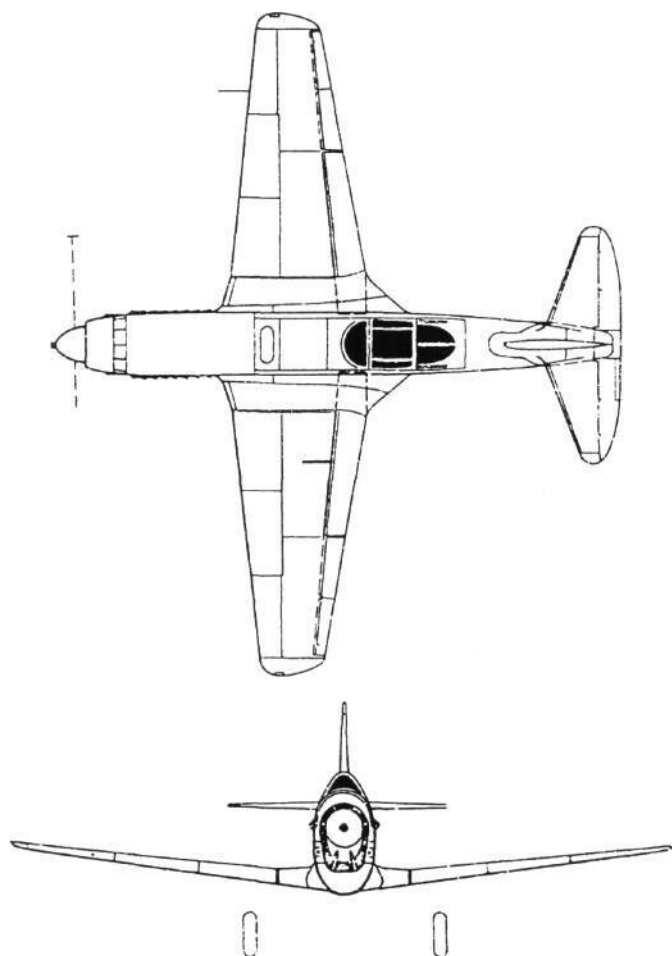
Photographs on the opposite page:

Top: I-250 No1.

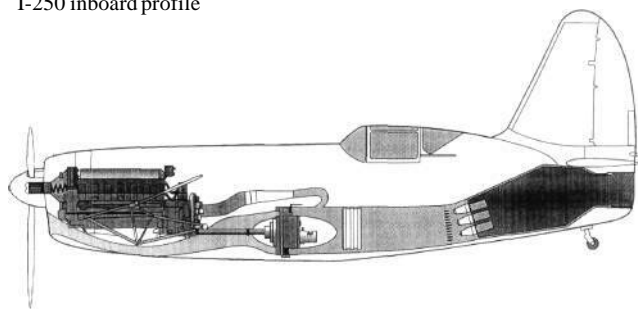
Centre: I-250 No2.

Bottom: Production MiG-13 (straight propeller blades).

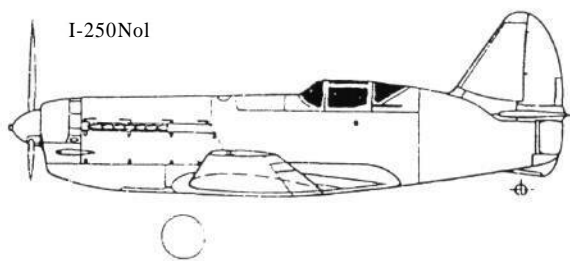
I-250 No1/No 2, MiG-13



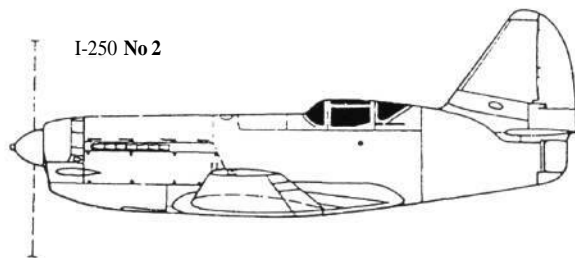
I-250 inboard profile



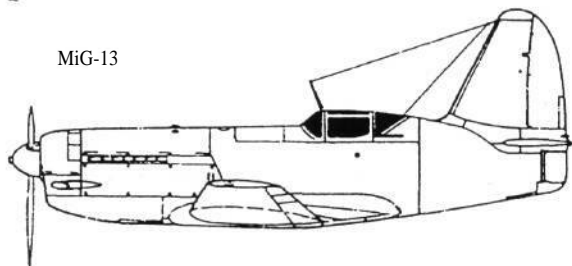
I-250No1



I-250 No 2



MiG-13



MiG I-270, Zh

Purpose: To investigate the potential of a rocket-propelled interceptor.

Design Bureau: OJB-155 of A I Mikoyan.

As a major (in most respects the greatest) pioneer of rocket-propelled aircraft, the Soviet Union was intrigued to capture examples of the Messerschmitt Me 163 and Me 263 (Ju248). In 1944 the MiGOKB produced 'doodles' of Me 163 type aircraft, but in 1945 the bureau received a contract to build two prototypes of a rocket interceptor (a similar contract was awarded to A S Moskalyov). The MiG aircraft was designated >K, the Cyrillic character sounding like the s in 'measure', represented in English as Zh, and given the official designation I-270. To prepare for the aircraft's handling qualities several OKB and NII-WS pilots practised with a Yak-3 overloaded by lead bars. The first I-270 was ready for flight well before its propulsion system. The rocket engine was simulated by an inert mass in the tail, but the Zh-01 was still well below normal weight because it lacked propellants, armament, radio and the windmill generator, in early December 1946 VN Yuganov began testing it as a glider at speeds up to 300km/h (186mph), casting off from a Tu-2 tug. At the start of 1947 Zh-02 was ready, with propulsion, and it began testing (precise date not recorded), the assigned pilot being A K Pakhomov of the WS. On an early flight

he made a badly judged landing which damaged 02 beyond economic repair. A few weeks later Yuganov belly-landed 01, and again nobody bothered to repair it.

Generally similar in layout to the Ju 248, except for the prudent addition of a high-mounted horizontal tail, the I-270 was of course all-metal. The small wing had a laminar profile, fixed leading edge, slotted flaps and conventional outboard ailerons. Structurally it was unusual in having five spars. The tail comprised a large fin and mass-balanced rudder and a small tailplane with elevators which, like the ailerons, had bellcrank fairings on the underside. The circular-section fuselage had the wing amidships at mid-depth, attached from below as a single unit. The cockpit in the nose was pressurized by air bottles, and the seat could be ejected by a cordite gun. The tricycle landing gear had a track of only 1.6m (5ft 5in) despite the main wheels being inclined slightly outwards. Wheelbase was 2.415m (7ft 11in), the nose unit being steerable. Each unit retracted forwards, power for the landing gear and flaps being provided by air bottles. The rocket engine was an RD-2M-3V, developed by L S Dushkin and V P Glushko. The fuselage behind the cockpit was almost entirely occupied by four tanks housing 1,620kg (3,571 lb) of RFNA (red fuming nitric acid) and 440kg (970 lb) of kerosene. These were initially fed

by an electrically driven pump, of Me 163 type. As the liquids reached the chamber they were automatically ignited by injection of high-test hydrogen peroxide, of which 60kg (132 lb) was provided in seven stainless-steel bottles. Once operating, the engine was fed by turbopumps driven by the propellants themselves. The engine had one main thrust chamber, rated at sea level at 1,450kg (3,197 lb), and an auxiliary chamber rated at 400kg (882 lb). Take-off and initial climb was normally made with both in operation, when endurance was about 41/2min. In cruising flight, with the small chamber alone in use (high-altitude thrust being about 480kg, 1,058 lb), endurance was 9min. An electrical system was served by a battery charged by an Me 163 type windmill generator on the nose. RSI-4 radio was fitted, with an external wire antenna, and armament comprised two NS-23 with 40 rounds each. A plan to fit four RS-82 rockets under the wings was not actioned.

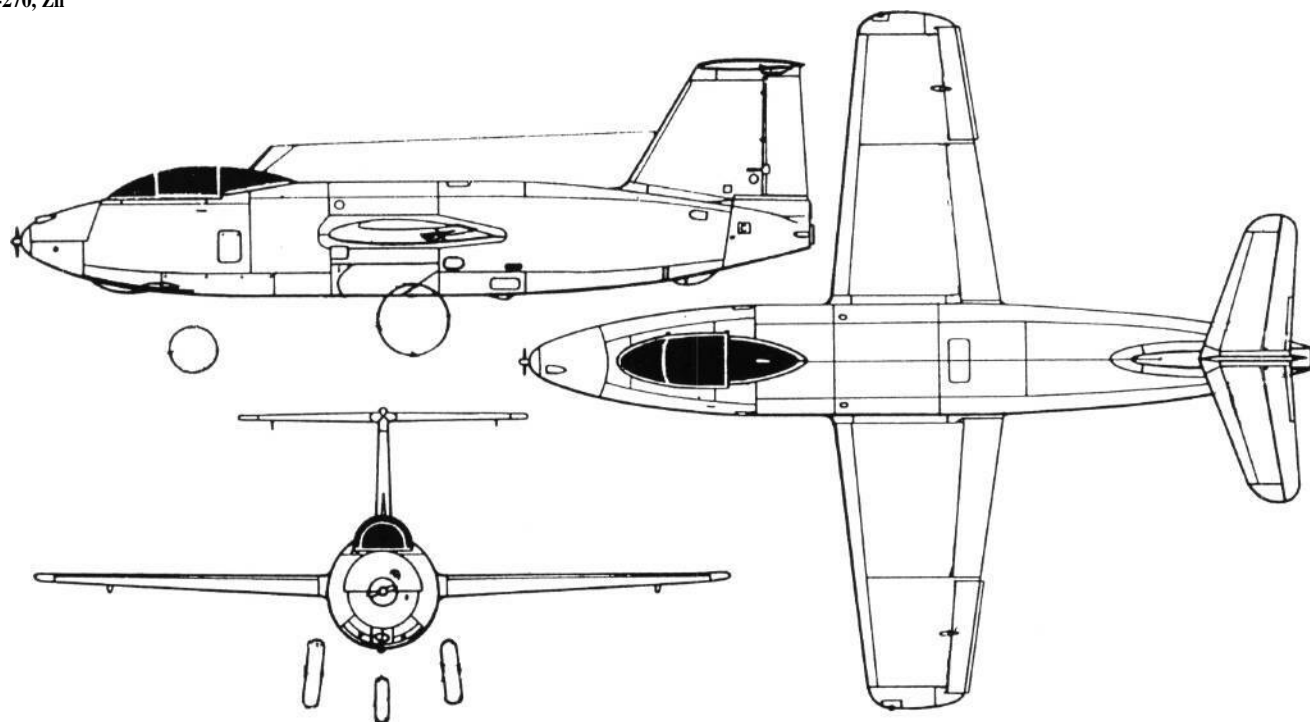
By the time they were built these aircraft were judged to be of no military importance.

Photographs on the opposite page:

Top right: Zh-01, without engine.

Three views of I-270, Zh-02.

I-270, Zh



Dimensions

| | | |
|----------|--------------------|--------------------|
| Span | 7.75m | 25 ft 5 in |
| Length | 8.915m | 29 ft 3 in |
| Wingarea | 12.0m ² | 129ft ² |

Weights

| | | |
|--------------------|-----------------|----------------|
| Empty (Zh-02) | 1,893kg | 4,173lb |
| Acid/fuel/peroxide | 1,620/440/60 kg | total 4,674 lb |
| Loaded | 4,120kg | 9,083 lb |

Performance

| | | |
|---------------------------|--------------|------------|
| Maximum speed | | |
| at sea level about | 936km/h | 582 mph |
| at high altitude | 1,000km/h | 621 mph |
| Time to climb to 10,000m | 2.37 min | (32,800ft) |
| Service ceiling | 17,000m | 55,775ft |
| Range | not measured | |
| Take-off run | 895m | 2,936 ft |
| Landing speed (tanks dry) | 137km/h | 85 mph |
| Landingrun | 493m | 1,617ft |



MiG-9L, FK

Purpose: To test the guidance system of a cruise missile.

Design Bureau: OKB-155 of AI Mikoyan.

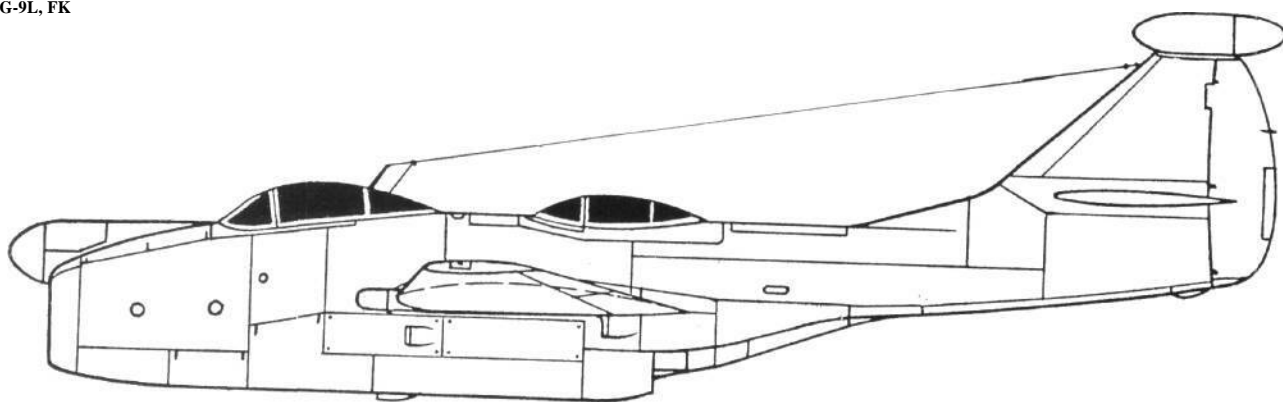
In late 1947 the Kremlin ordered the development of a large cruise missile which could be launched (primarily against ships) from the Tu-4. Because of the importance of this project it was assigned to a joint team formed by OKB No 155 (MiG) and a new semi-political group called SB-1 (Special Bureau No1). The OKB assigned one of the founders, M I Gure-

vich, as titular head, but the Chief Designer was A Ya Berezhnyak who has figured previously on page 29 of this book. Head of SB-1 was S L Beria, son of the formidable Politburo member who in 1953 succeeded Stalin. In fact, SB-1 faded from the scene, as it had little to contribute, though it did have P N Kusenko as Chief Designer. Under intense pressure a swept-wing turbojet-engined missile was created, which later went into production as the KS-1 Komet. In early 1949 its guidance system was tested in an Li-2 (Soviet derivative of

the DC-3), and later in that year a more representative system was tested in the FK (also called MiG-9L, Laboratoriya). This was too large to be carried aloft by a Tu-4, so it formed with the Tu-4 parent aircraft and thence simulated the missile on its flight to the target. Subsequently this aircraft was used to test different cruise-missile guidance systems, assisted by the K-1, a manned version of the KS-1 missile.

Aircraft FK was a modified MiG-9 twin-jet fighter, the first type of turbojet aircraft to fly in

MiG-9L, FK



MiG-9L, FK



the Soviet Union. Features included a straight-tapered wing of laminar profile of 9% thickness with large slotted flaps and Frise ailerons, a pressurized cockpit ahead of the wing, a ground-adjustable tailplane mounted part-way up the fin, a nosewheel retracting forwards and main landing gears retracting outwards, and a nose inlet feeding air to two RD-20 turbojets (Soviet copies of the German BMW 003A, each rated at 800kg, 1,764lb, thrust) mounted under the wing with jet nozzles under the trailing edge. The final production series had an ejection-seat, and the FK was from this batch. The heavy nose armament of three NS-23K guns and all armour

were removed, and the fuselage was extended by splicing in an extra section accommodating an unpressurized rear cockpit with a side-hinged canopy for the guidance-system operator. As in the Komet, the missile's radar dish antenna was mounted above the nose, and a receiver antenna was mounted on the leading edge of each wing. Above the fin was a streamlined container housing the aft-facing transmitter and receiver antennas for the radio-command guidance from the parent aircraft after launch. Once the autopilot had set the correct course the nose radar homed on the parent's radar signals reflected back from the target. Nearer the target the missile's

own radar became active, steering by signals received by the leading-edge antennas.

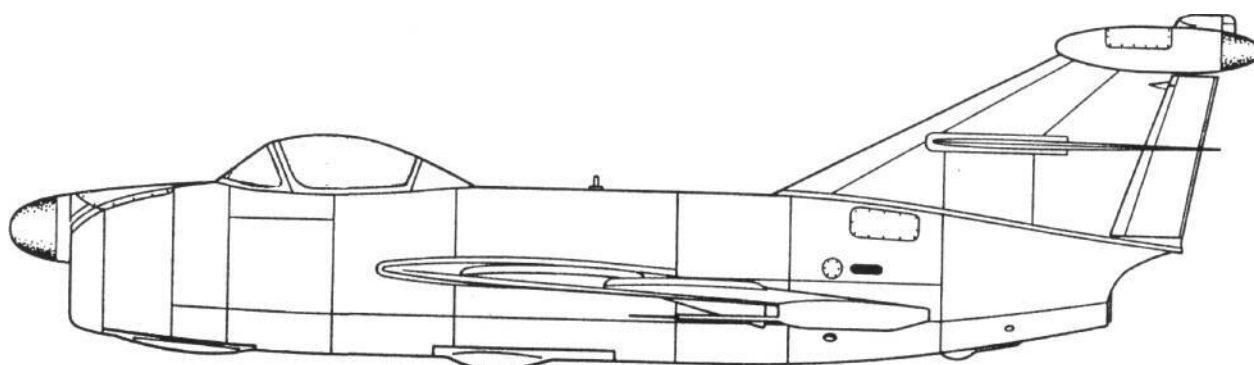
So far as is known, the FK played a valuable role in the development of one of the world's first turbojet cruise missiles. So did the KSK, a piloted version of the missile itself.

Dimensions (FK)

| | | |
|-----------|--------------------|----------------------|
| Span | 10.0m | 32ft9" Kin |
| Length | 10.12m | 33 ft 2 in |
| Wing area | 18.2m ² | 195.9ft ² |

No other data.

K-1, or KSK, manned version of Komet



K-1, KSK



MiG-15 Experimental Versions

Design Bureau: In most cases, the OKB-155 of AI Mikoyan.

Made possible by Britain's export of Rolls-Royce Nene turbojets to Moscow in September 1946, the Aircraft S marked a dramatic leap forward in Soviet fighter design. First flown on 30th December 1947, it was far ahead of any other fighter in Europe. In 1949 it went into large-scale production as the MiG-15. In the Korean war (1950-53) it completely outperformed Allied aircraft (the F-86 was the only rival in the same class) and put the name 'MiG' in the limelight around the world, where it remains to this day. A total of 11,073 of all versions were constructed in the USSR, and the global total exceeded 16,085 (the Chinese output is not known precisely). Many have served in experimental programmes. These, and other MiG types, require treatment that is not apposite in the context of this book. What follows therefore is the specification for a typical standard late production version, the MiG-15b/s, incorporating numerous aerodynamic, control, systems and engine improvements over the original MiG-15. Much more detail of experimental MiG-15s will be included in an *Aerofax* on the MiG-15 which will be published in 2001. The engine of the MiG-15b/s was the VK-1, derived from the Nene and rated at 2,700kg (5,952 lb).

| | | |
|-------------------------|--------------------|-----------------------|
| Dimensions | | |
| Span | 10.085m | 33 ft 1 in |
| Length (excluding guns) | 10.102m | 33 ft 1 1/2 in |
| Wing area | 20.6m ² | 221.75ft ² |
| Weights | | |
| Empty | 3,681 kg | 8,115lb |
| Internal fuel | 1,173kg | 2,586 lb |
| Loaded (clean) | 5,055 kg | 11,144 lb |
| (maximum) | 6,106kg | 13,461 lb |
| Performance | | |
| Max speed at sea level | 1,076km/h | 669 mph |
| at 3,000m (9,842 ft) | 1,107 km/h | 688 mph |
| Rate of climb (clean) | 46m/s | 9,055 ft/min |
| Service ceiling | 15,500m | 50,850 ft |
| Range (clean) | 1,330km | 826 miles |
| Take-off (clean) | 475m | 1,558ft |
| Landing speed/ | 178 km/h | 111 mph |
| run | 670m | 2,198ft |

SU

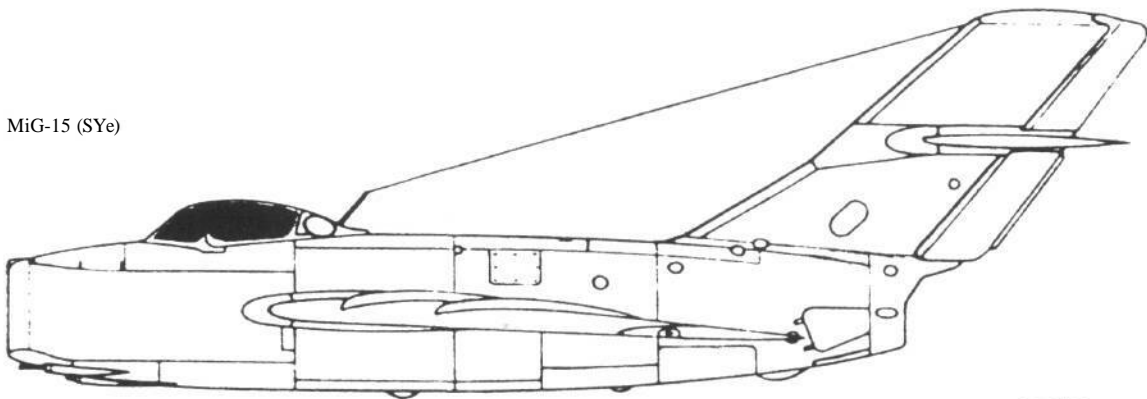
One of the experimental versions of the basic (not £>/s) aircraft was given the OKB designation SU. Originally a standard fighter, MiG-15 No 109035, with callsign 935 painted on the fuselage, it was used to test the V-I-25/Sh-3. This was the designation for a fighter armament system developed by the Shpital'nyi weapons bureau. The standard quick-change armament pack housing one 37mm and two 23mm guns was replaced by a fixed installation of two powerful Sh-3 23mm guns, each

with 115 rounds. Each gun was mounted below the fuselage in a streamlined fairing. The barrel projected through a vertical slot so that, mounted on trunnions and driven by an irreversible electric screwjack, it could be elevated to +11° and depressed to -7° (there was no lateral movement). The Ministry order for this conversion was signed on 14th September 1950, and the SU was factory-tested between 2nd January and 27th March 1951. NII-WS testing followed from 30th June to 10th August 1951. The general opinion was that in tight turning combat the system was useful in bringing the guns to bear, and it also enabled a head-on attack to be made with less risk of collision. The NII-WS report called for a better sight, and for the guns to pivot over a greater angular range.

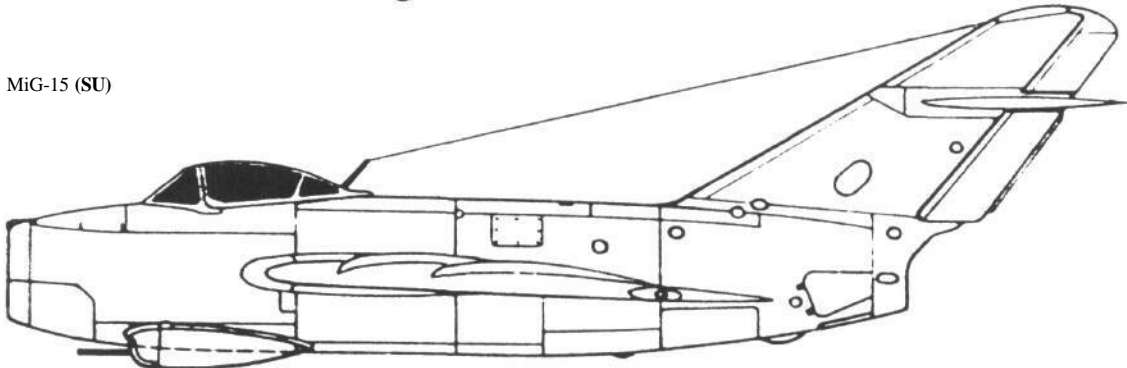
SYe

Written SE in Cyrillic characters, this was a tangible result of years of research into the endemic problem of poor or even reversed lateral control, wing drop and inadequate yaw (directional) control, especially at high Mach numbers. Most of the research was done at CAHI (TsAGI), but two workers at LII-MAP (the Ministry flight research insti-

MiG-15 (SYe)



MiG-15 (SU)



tute), IM Pashkovskii and DI Mazurskii, also took a hand. After various tests they made recommendations to AI Mikoyan, who ordered the OKB to construct two SYe aircraft, based on the MiG-15/s. An obvious modification was that the fin leading edge was kinked to maintain a broad chord to the top. Among other changes the wings were stiffened and fitted with ailerons of higher aspect ratio ending in square tips. The first SYe, call-sign 510, was assigned to LII-MAP pilot D M Tyuterev, who dived it to Mach 0.985 despite having unboosted ailerons. The ailerons were then fitted with BU-1 boosters, whereupon on 18th October 1949 Tyuterev dived it to beyond Mach 1, the first MiG aircraft to achieve this.

Burlaki

One of the deeper problems of the Soviet ADD (Strategic Aviation) was how to escort the Tu-4. No fighter, especially a jet, had anything like adequate range. Aircraft designer AS Yakovlev suggested making the bombers tow fighters to the target area (see Yak-25E). Mikoyan briefly worked on a similar Burlaki (barge-hauler) scheme, fitting a MiG-15/s with a harpoon clamp above the nose which the pilot could hook on a crossbar at the end of a long cable reeled out from the Tu-4. If hostile fighters were encountered the MiG pilot would start the engine, release the tow and engage combat. In theory he could then hook on



MiG-15 (SYe) test-bed.

again for the ride home. It was not considered a viable idea, one reason being that with the engine inoperative the MiG pilot had no cockpit pressurization and also became frozen.

Refuelling test-beds

An alternative to the Burlaki method was Dozpravka v Vozduke, refuelling in flight. Extensive trials took place in 1949-53 using

various MiG-15s and Tu-4 tankers. Eventually a system was used almost identical to that devised by the British Flight Refuelling Ltd, with hoses trailed from the tanker's wingtips and a probe on the nose of the fighter. Apart from the basic piloting difficulty, problems included probe breakage, pumping of bulk fuel into the fighter's engine and the need for an improved beacon homing method for finding the tanker at night or in bad weather.

MiG-17 Experimental Versions

Design Bureau: OKB-155 of AI Mikoyan.

Throughout 1949 the MiG OKB was busy creating the SI, the prototype of a MiG-15 derivative incorporating numerous improvements. Most of these were aerodynamic, including a completely redesigned wing, a horizontal tail of increased sweep on an extended rear fuselage, and improved flight controls. The first flight article, SI-2, was flown on 13th January 1950, and on 1st September 1951 MAP Order No 851 required the SI to be put into production as the MiG-17. Because of the sheer momentum of MiG-15 production the improved aircraft did not replace it in the factories until October 1952. The following specification refers to the MJG-17F, by far the most important version, which was powered by the afterburning VK-1F, with a maximum rating of 3,380kg (7,451 lb).

| | | |
|-----------------------------|----------------------|-----------------------|
| Dimensions | | |
| Span | 9.628 m | 31 ft 7 in |
| Length | 11.26m | 36 ft 1 Min |
| Wing area | 22.64 m ² | 243.7 ft ² |
| Weights | | |
| Empty | 3,940kg | 8,686 lb |
| Fuel/oil | 1,170kg | 2,579 lb |
| Loaded (clean) | 5,340kg | 1 1,772 lb |
| (maximum) | 6,069 kg | 13,380 lb |
| Performance | | |
| Maximum speed | | |
| at sea level | 1,100km/h | 684 mph |
| at 3,000m (9,842 ft) | 1,145km/h | 71 1.5 mph |
| Mach limit | | |
| (clean over 7,000m) | 1.15 | 22,966ft |
| Time to climb (afterburner) | | |
| to 5,000 m | 1.8min | 16,404ft |
| to 10,000m | 3.7 min | 32,808ft |
| Service ceiling | | |
| (still climbing 3.6 m/s) | 16,600m | 54,462 ft |
| Range (clean) | 1,160km | 721 miles |
| (maximum) | 1,940km | 1,205 miles |
| Take-off speed/ | 235km/h | 146 mph |
| run | 590m | 1,936ft |
| Landing speed/ | 180km/h | 112 mph |
| run | 850m | 2,789 ft |

SN

In late 1953 the MiG Factory 155 produced an experimental fighter representing the next stage beyond the SU. This time the entire forward fuselage was redesigned to house the pivoted guns, the engine being fed by lateral inlets and ducts passing both above and below the wing torsion box (which was given front and rear fairings). Ahead of Frame 13 the entire nose was occupied by the SV-25 armament installation devised by the TKB (Tula design bureau) of Afanas'yev and Makarov. This was based on a large frame mounted on needle-roller bearings on each side and pivoted on a transverse axis over the range +27° 267-9° 28' (not 9° 48' as previously published). On this frame were mounted three TKB-495 lightweight 23mm guns, fed by box magazines mounted on the fixed structure. The whole installation weighed 469kg (1,034lb), requiring a balancing increase in the size of Tank 3 in the rear fuselage. As this

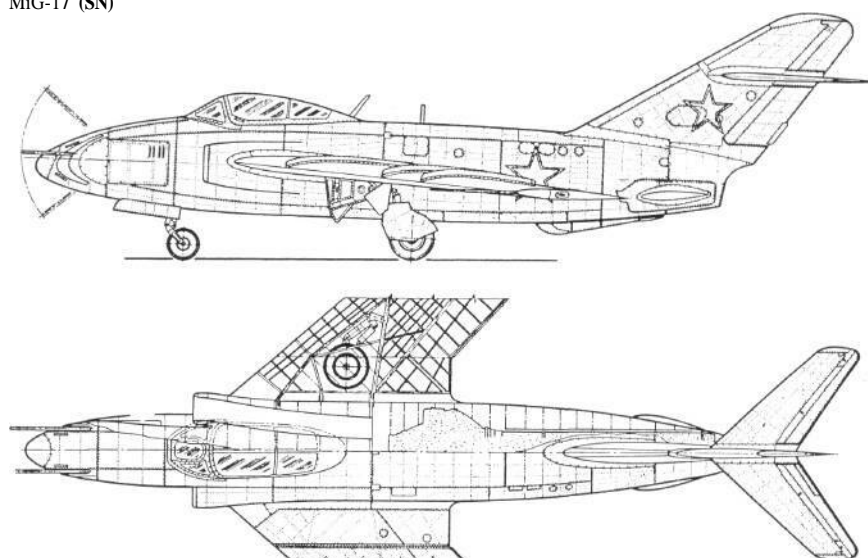


aircraft was so non-standard anyway the OKB took the opportunity to try a few other changes. Of course a special gunsight was needed, and it may have been to improve the optics that a new windscreen was designed, wider and longer than before and giving a better field of view ahead. The SN was factory-tested by Georgiy K Mosolov from mid-1953. It proved a failure, with seriously reduced flight performance and useless armament. Because the guns were so far ahead of the centre of gravity and centre of pressure of the aircraft, firing them at large angles from the horizontal caused powerful pitching moments which threw the aim off-target. Mikoyan decided the problem was not readily soluble. Numerous otherwise unmodified MiG-17s were also used as armament test-beds.



Two different SDK-5s.

MiG-17 (SN)



SI-10

This MiG-17 was one of the original type with the non-afterburning VK-1A engine, with call-sign 214. Having studied the wing and tail of the F-86E Sabre, this aircraft was fitted with important aerodynamic and control changes. The wing was fitted with large automatic slats over the outer 76 per cent of each leading edge, large area-increasing (Fowler-type) flaps, and spoilers (called interceptors) under the outer wings which opened whenever the adjacent aileron was deflected more than 6°. In addition, a fully powered irreversible tailplane was fitted, with limits of +37-5°, retaining the elevators driven by a linkage to add camber. Grigori A Sedov flew No 214 on 27th November 1954, followed by many other OKB and NII-WS pilots. Opinions were favourable, especially regarding the horizontal tail, but it was not worth disrupting MiG-17 production to incorporate the changes.

SDK-5

Already used for a MiG-15, this designation was repeated for MiG-17s used for further tests of the guidance system of the KS-1 Komet cruise missile. The original test-bed for this system had been the MiG-9L, and like that aircraft the SDK-5 had forward-facing antennas on the nose and wings and an aft-facing antenna above the tail. Like the MiG-9L this aircraft later assisted development of the large supersonic Kh-20 (X-20) missile.

Photograph on the opposite page:

MiG-19 (SM-10).

MiG-19 Experimental Versions

Design Bureau: OKB-155 of A I Mikoyan

Throughout the massive production of the MiG-15 and MiG-17, with a combined total exceeding 22,000, the MiG OKB was eager to discard the British-derived centrifugal engine and build truly supersonic fighters with indigenous axial engines. It achieved this in sensible stages. The M, or I-350, introduced the large TR-3A axial engine and a wing with a leading-edge sweep of 60°. The SM-2, or I-360, powered by twin AM-5 axial engines, at first was fitted with a high T-type tail. Then the tailplane was brought down to the fuselage, the design was refined, and as the SM-9 with afterburning engines (first flown 5th January 1954) achieved production as the MiG-19. The SM-9/3 introduced the one-piece 'slab' tailplane, with no separate elevator, and this was a feature of the MiG-19S. Powered by two RD-9B engines each with an afterburning rating of 3,250kg (7,165lb), this had the devastating armament of three NR-30 guns, each far more powerful than the British Aden of the same calibre. The following specification is for a typical MiG-19S.

| | | |
|-----------------------------|---------------------|----------------------|
| Dimensions | | |
| Span | 9.00m | 29 ft 6 1/2 in |
| Length (excl air-data boom) | 14.8m | 48 ft 6 1/2 in |
| Wing area | 25.16m ² | 271 ft ² |
| Weights | | |
| Empty | 5,455kg | 12,026lb |
| Loaded (clean) | 7,560kg | 16,667lb |
| (maximum) | 8,832 kg | 19,471 lb |
| Performance | | |
| Max speed at sea level, | 1,150km/h | 715 mph |
| at 10,000 m (32,808 ft) | 1,452km/h | 902 mph (Mach 1.367) |
| Time to climb to 10,000m | 1.1 min | 32,808ft |
| to 15,000m | 3.7 min | 49,215ft |
| Service ceiling | 17,500m | 57,415ft |
| Range (clean) | 1,390km | 864 miles |
| (two drop tanks) | 2,200km | 1,367 miles |
| Take-off run (afterburner) | 515m | 1,690ft |
| Landing speed/run | 235 km/h | 146 mph |
| using parabrate | 610m | 2,000 ft |

SM-10

Though it had a generally longer range than its predecessors the MiG-19 was required in a decree of May 1954 to be developed with flight-refuelling capability. At that time the only tanker was a version of the piston-engined Tu-4, and a series MiG-19, callsign 415, was fitted with a probe above the left (port) wingtip, feeding into a large pipe with diverters and non-return valves to fill all the aircraft tanks. By 1956 testing had moved to an extraordinary test-bed, callsign 10, fitted with no fewer than four probes. One was at the bottom of the nose, another at top left on the nose, a third on the leading edge of the port

wing and the fourth projected with a kink from above the starboard wing.

SM-20

This was a MiG-19S modified as a pilotless aircraft to test the guidance system of the Kh-20 cruise missile. This huge weapon was designed to be carried under a special version of the Tu-95 heavy bomber, and one Tu-95K was modified to carry and release the SM-20. Apart from being equipped with the missile's guidance system and a special autopilot and various other subsystems, including a receiver link for remote-pilot guidance, the fighter was fitted with a position beacon, radar reflector and destruct package. Suspension lugs were built in above the centre of gravity, and the parent aircraft had pads which pressed on each side of the SM-20 canopy. Tests began in October 1956. SM-20P described the aircraft after modification with special engines able to vaporise the fuel to ensure reliable starting at high altitudes.

SM-30

This designation applied to MiG-19 and MiG-19S aircraft modified for ZELL (zero-length launching). Nuclear weapons clearly made it foolish to base combat aircraft on known airfields, so the ZELL technique was intended to enable aircraft to be fired off short inclined launchers by a large rocket. The launcher was naturally made mobile, and most locations were expected to be in the extreme Arctic such as Novaya Zemlya. The aircraft needed a strengthened fuselage, reinforced fuel tanks and mounts, a special pilot headrest, and (in most cases) extra-large parabrates or arrester hooks for short landings.

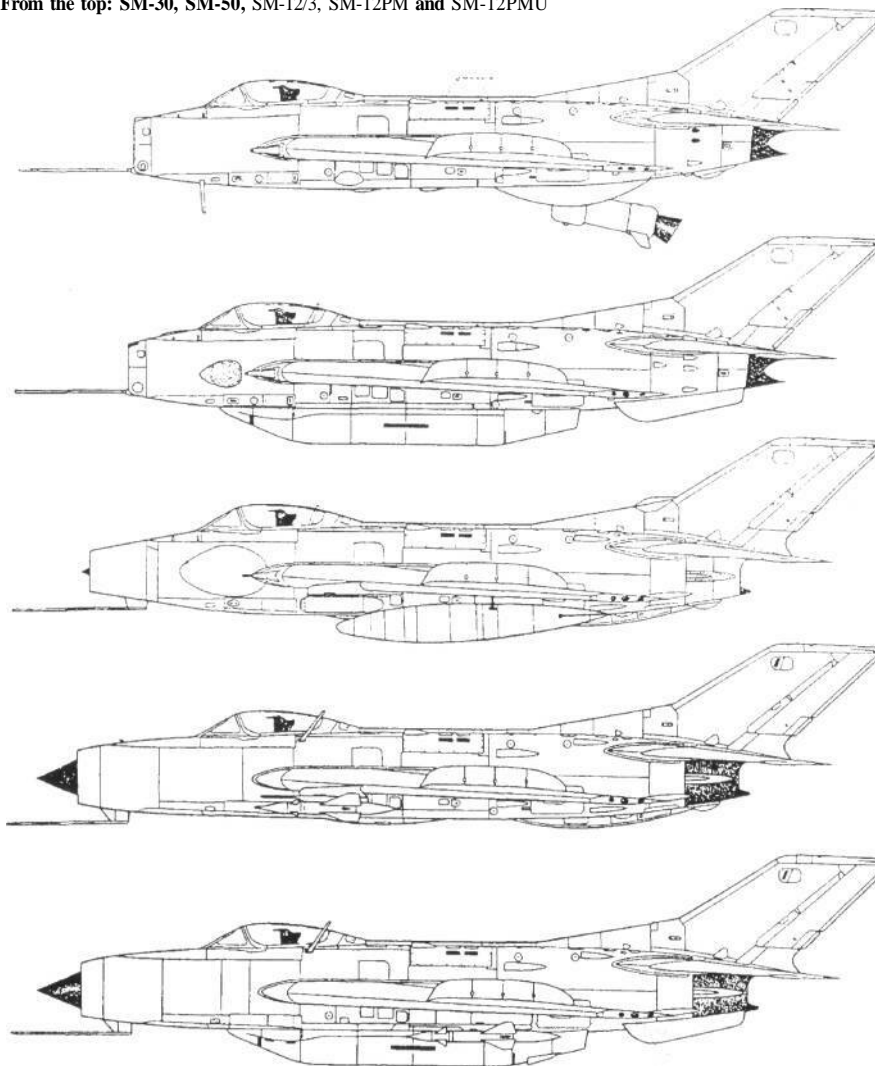
The usual rocket was the PRD-22, with a thrust of 40,000kg (88,185 lb) for 2.5 seconds. Manned firings took place from 13th April 1957, the chief pilots being G Shiyarov and Yu A Anokhin (not the more famous S N Anokhin). Results were satisfactory, but the scheme was judged impractical.

SM-50

This designation applied to the MiG-19 fitted with a booster rocket engine in a pod underneath. Whereas previous mixed-power fighters had been primarily to test the rocket, the SM-50 was intended as a fast-climbing fighter, able very quickly to intercept high-flying bombers. The first SM-50 was a MJG-19S fitted with a removable ventral pack called a U-19 (from Uskoritel', accelerator). Made at the MiG OKB, this was basically formed from two tubes arranged side-by-side with a nose fairing. It contained an RU-013 engine from L S Dushkin's KB, fed by turbopumps with AK-20 kerosene and high-test hydrogen peroxide. The pilot could select either of two thrusts, which at sea level were 1,300kg (2,866lb) or 3,000kg (6,614lb). To avoid the rocket flame the aircraft's ventral fin was replaced by two vertical strake-fins under the engines (which were RD-9BM turbojets with variable afterburning thrust but unchanged maximum rating). The first SM-50 began factory testing (incidentally after the Ye-50, and long after the first MiG-21 prototypes) in December 1957. Despite a take-off weight of 9,000kg (19,841 lb) a height of 20,000m (65,617ft) was reached in under eight minutes with the rocket fired near the top of the climb, boosting speed to 1,800km/h (1,118mph, Mach 1.695). Dynamic zoom ceiling was estimated at 24,000m (78,740ft). Five pre-production SM-50s were built at Gor'kiy, but they were used only for research.



From the top: SM-30, SM-50, SM-12/3, SM-12PM and SM-12PMU



SM-12

Early in the production of the MiG-19 it was realised that the plain nose inlet was aerodynamically inefficient at supersonic speeds, and that a properly designed supersonic inlet would enable maximum speed to be significantly increased without any change to the engines. By the mid-1950s the OKB was well advanced with the prototypes that led to the MiG-21 and other types, all of which had inlets designed for supersonic flight. In fact production of the MiG-19 in the Soviet Union was quite brief - it was left to other countries to discover what a superb fighter it was - and all had the original inlet. A total of four SM-12 (plus two derived) aircraft were built, with the nose extended to terminate in a sharp-lipped inlet. As in standard MiG-19s, across the inlet was a vertical splitter to divide the airflow on each side of the cockpit. This was used to support a conical centrebody whose function was to generate a conical shock-wave at supersonic speeds. For peak pressure recovery, to keep the shock cone focussed on the lip of the inlet the cone could be translated (moved in or out) by a hydraulic ram driven by a subsystem sensitive to Mach number. A similar system has been used on all subsequent MiG fighters, though the latest types have rectangular lateral inlets. SM-12/1 was powered by two RD-9BF-2 engines with a maximum rating of 3,300kg (7,275 lb). SM-12/2, /3 and /4 were powered by the R3-26, with a maximum rating of 3,800kg (8,377 lb). All four SM-12 aircraft were fitted with improved flight control systems, wing guns only and new airbrakes moved to the tail end of the fuselage. A fifth aircraft, designated SM-12PM, was fitted with pylons for two K-5M guided missiles, which were coming into production as the RS-2U. This required a guidance beam provided by an RP-21 (TsD-30) interception radar. The scanner necessitated a greatly enlarged nosecone, which in turn demanded a redesigned forward fuselage with hardly any taper. Both guns were removed, and there were many other modifications. The sixth and final version was the SM-12PMU, armed with two or four RS-2U missiles. This aircraft was intended to intercept high-altitude bombers faster than any other aircraft, so it combined two R3-26 engines with the U-19D rocket package. Numerous MiG-19 variants served as armament test-beds, mainly for guided missiles.

Left: Rocket pack of SM-50.

Opposite page, top to bottom:

SM-30 on launcher.

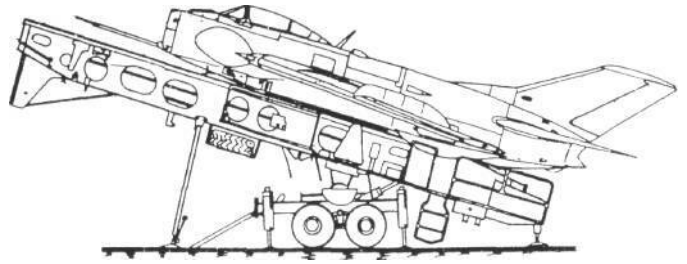
SM-12/1.

SM-12/3 and SM-12PM with supersonic tanks.

SM-12PMU with K-5 (RS-2U) guided missiles.



SM-30 on launcher



MiG Experimental Heavy Interceptors

Purpose: To create a supersonic missile-armed all-weather interceptor.

Design Bureau: OKB-155 of A I Mikoyan

I-3U, I-7U, I-75

In the second half of the 1950s the 'MiG' design team created a succession of interceptor fighters which began by reaching 870mph and finished 1,000mph faster than that. The first was the I-1, first flown on 16th February 1955, which resembled a MiG-19 powered by a single large VK-7 centrifugal engine. After a major false start, this led to the I-3U, which (contrary to many reports) was flown in late 1956 on the 8,440kg (18,607lb) thrust of a VK-3 bypass jet (low-ratio turbofan). By this time the aerodynamic shape, and indeed much of the structure and systems, was extraordinarily similar to the contemporary Sukhoi prototypes. The next stage was the I-7U, flown on 22nd April 1957, which used the engine picked earlier by Sukhoi, the excellent Lyul'ka AL-7F rated at 9,210kg (20,304lb). In turn this was rebuilt into the I-75, first flown on 28th April 1958. This was the first of the family of impressive MiG single-engined heavy interceptors, with powerful radar (Uragan [hurricane] 5B) and armed only with missiles (two large Bisnovat K-8). A second aircraft was built from scratch, designated I-75F and powered by the uprated AL-7F-1 with a maximum thrust of 9,900kg (21,825lb). The following specification refers to the I-75.

| | | |
|--------------------------------------|--------------------|---|
| Dimensions | | |
| Span | 9.976 m | 32 ft 9 ¹ / ₂ in |
| Length | 18.275m | 59 ft 11 ¹ / ₂ in |
| Wing area | 31.9m ² | 343 ft ² |
| Weights | | |
| Empty | 8,274 kg | 18,241 lb |
| Internal fuel | 2,100kg | 4,630 lb |
| Loaded (clean) | 10,950kg | 24,140 lb |
| (maximum) | 11,470kg | 25,287 lb |
| Performance | | |
| Maximum speed | | |
| clean, at 11,000 m (36,089 ft) | 2,050 km/h | 1,274 mph (Mach 1.93) |
| with missiles | 1,670 km/h | 1,038 mph (Mach 1.57) |
| Time to climb to 6,000 m (19,685 ft) | | 0.93min |
| Service ceiling | | |
| (Mach 1.6 in afterburner) | 19,100 m | 62,664ft |
| Range (internal fuel) | 1,470 km | 913 miles |
| Take-off run | 1,500m | 4,921 ft |
| Landing speed/run with parabake | 240 km/h | 149 mph |
| | 1,600m | 5,249ft |

Ye-150

This was built specifically to test the remarkable R-15 turbojet, created by S K Tumanskii, initially working in A A Mikulin's KB, which he took over in 1956. This engine had been ordered to power future aircraft flying at up to Mach 3 (the first application was a Tupolev cruise missile). The MiG team led by Nikolai Z Matyuk predictably adhered to the proven formula of a tube-like fuselage with a variable multi-shock nose inlet, mid-mounted delta wing (the I-75 had had swept wings) and mid-mounted swept one-piece tailplanes. This time the fuselage had to accept the R-15-300 engine's take-off airflow of 144kg (317.51lb) per second, and the dry and reheat ratings of this engine were 6,840kg (15,080 lb) and 10,150kg (22,377lb). At high supersonic Mach numbers the thrust was greatly increased by the ejector-type nozzle, a very advanced propulsion system for the 1950s. As the Ye-150 was not a fighter the cockpit was enclosed by a tiny one-piece canopy of minimum drag. After prolonged delays, mainly caused by the engine, the aircraft was flown by A V Fedotov on 8th July 1960. It required frequent engine replacement, but among other things it reached 2,890km/h (1,796mph, Mach 2.72), climbed to 20km (65,617ft) in 5min 5 sec, and reached a sustained altitude of 23,250m (76,280ft).

Ye-152A

This was essentially an interceptor version of the Ye-150, but with the important difference that it was powered by a pair of mature R-11F-300 (early MiG-21 type) engines, with a combined maximum thrust of 11,480kg (25,309 lb). The airframe was designed to a load factor of 7, and 4,400 litres (968 Imperial gallons) of fuel was provided in six fuselage and two wing tanks, and provision was made for a centreline drop tank. The Ye-152A was designed for almost automatic interceptions, guided by the Uragan-5 ground-control system and its AP-39 autopilot, finally locking on its own TsP-1 radar and firing the two MiG-developed K-9-155 missiles carried on down-sloping underwing pylons. This fine aircraft was first flown by Mosolov on 10th July 1959 (more than a year before the Ye-150) and it reached 2,135km/h (1,327mph, Mach 2.01) at 13,700m (44,950ft). It caused a sensation when it made a flypast at the 1961 Tushino airshow, being identified by Western experts as the 'MiG-23' because that was the next odd number after the MiG-21. After a busy career it crashed in 1965.

Ye-152

This was intended to be the definitive heavy interceptor, combining the R-15-300 engine (uprated to 10,210kg, 22,509 lb) with the airframe and weapons of the Ye-152A. Two were built, Ye-152/1 and Ye-152/2. Apart from having a large single engine the obvious new feature was that the Ye-152/1 carried its K-9 missiles on down-sloping launch shoes on the wingtips. Internal fuel was slightly increased, and avionics were augmented. From its first flight on 21st April 1961 it was plagued by engine problems, but eventually set a 100km closed-circuit record at 2,401km/h (1,492 mph, Mach 2.26), a straight-line record at 2,681km/h (1,666mph, Mach 2.52) and a sustained-height record at 22,670m (74,377ft). These were submitted to the FAI as having been set by the 'Ye-166'. In fact both Mosolov and Ostapenko achieved 3,030km/h (1,883 mph, Mach 2.85). The Ye-152/2 was intended to have the Smerch (whirlwind) radar and associated Volkov K-80 missiles, but this was never incorporated. It first flew on 21st September 1961, and after a brief factory test programme was rebuilt into the Ye-152P.

Ye-152M

By the late 1950s the Mikoyan OKB had moved on to envisage this as the ultimate single-engined heavy interceptor. It was to have the R-15B-300 engine, with a maximum rating of 10,210kg (22,509 lb) and an improved propulsive nozzle of convergent/divergent form, considerably greater internal fuel capacity in an added fuselage spine, wingtip rails for the Volkov K-80 missile (later produced as the R-4R and R-4T), and many other modifications including canard foreplanes which this time were to be fully powered. The Ye-152/2 was rebuilt into the Ye-152P (from Perekhvatchik, interceptor) as a stepping stone to the Ye-152M. Externally it incorporated all the new features, including the roots for the foreplanes, but the surfaces themselves were not fitted. By the time the rebuild was complete the IA-PVO (manned fighter branch of the air defence forces) had selected the Tupolev Tu-128, and Mikoyan was well ahead with the far more impressive twin-engined MiG-25. In 1965 the Ye-152P, with the missile launchers replaced by more pointed wingtips, was put on display as the 'Ye-166', adorned with the details of the records set by the Ye-152/1. It still survives at the Monino museum in Moscow.

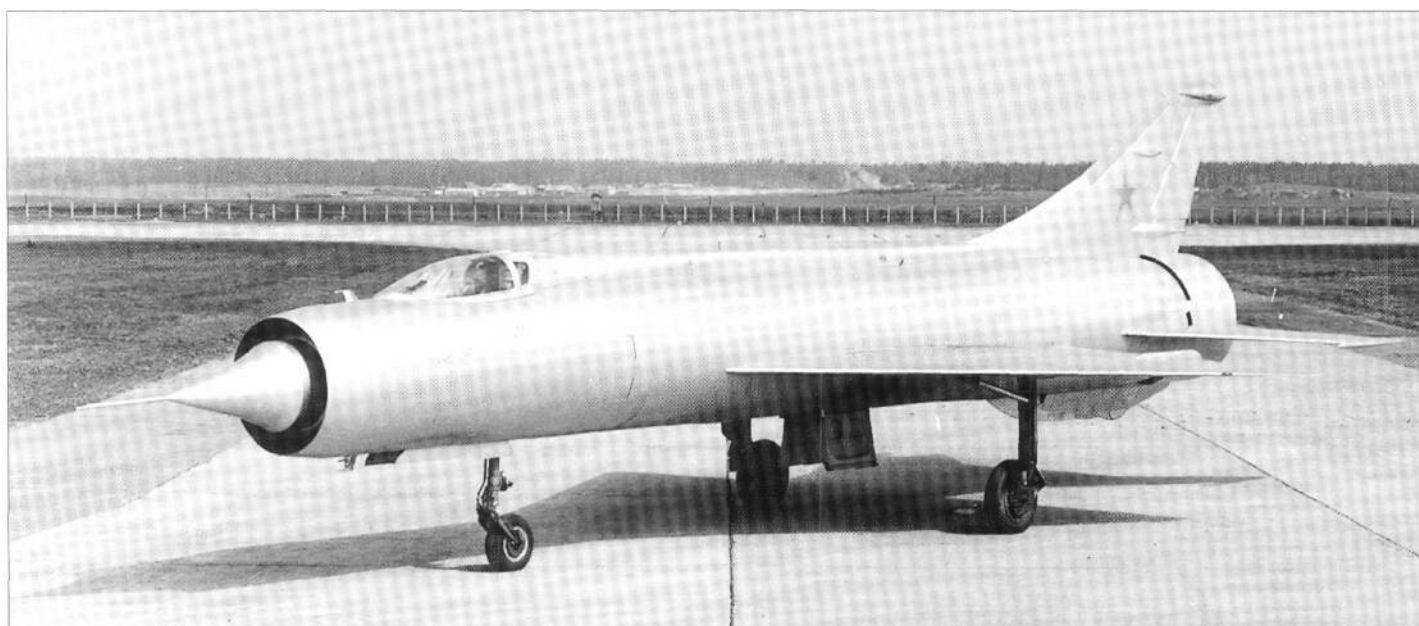
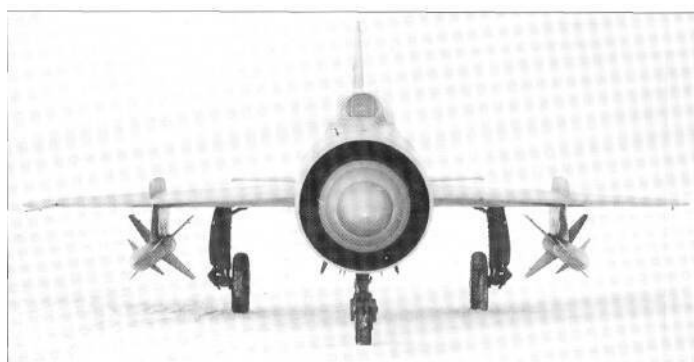


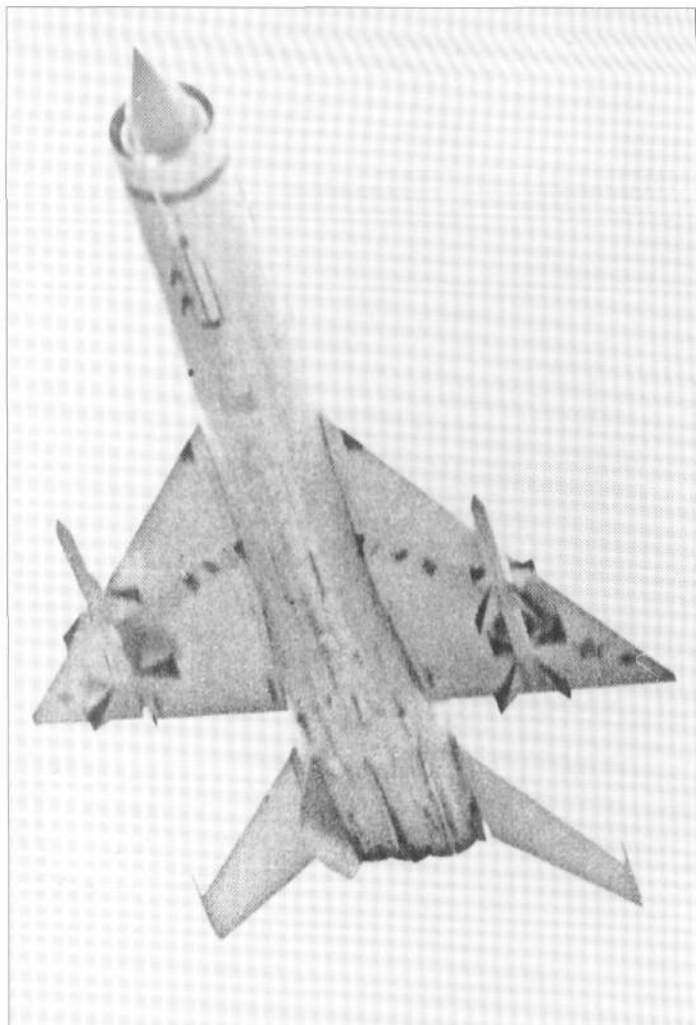
Top left: I-3U.

Top right: I-7U.

Above and right: Two views of I-75.

Bottom: Ye-150.







Photographs on the opposite page:

Top left: Ye-152A.

Top right: Ye-152A with K-9-155 missiles.

Centre: Ye-152A with K-9-155 missiles.

Bottom: Ye-152/1 with K-9-155 missiles.

Photographs on this page:

Above: Ye-152M project model.

Top left, centre and bottom right: Ye-152M with K-80 missile mock-ups.

Top right: Ye-152M record version (so-called 'Ye-166') at Monino.

MiG-21 Experimental Versions

Design Bureau: OKB-155 of AI Mikoyan.

Ye-2, Ye-4, Ye-5

The Korean War of 1950-53 triggered a significant acceleration of development of weapons in the Soviet Union. For the first time the 'MiG' OKB found itself working under intense pressure on two distinct classes of fighter. The first to be launched were the big radar-equipped interceptors typified by a wing area of 30m² (323ft²) and engines in the thrust range 9,072 to 13,608kg (20,000 to 30,000 lb). The second family were small but agile fighters intended for close visual combat, characterised by wings of some 22m² (237ft²) and engines in the 5,000kg (11,020 lb) class. The smaller aircraft were required to reach Mach 2 on the level at heights up to 20km (65,617ft) whilst carrying guns and a radar-ranging sight. Intensive tunnel testing failed to show clear superiority between a swept wing rather like a small version of that of the MiG-19, with a leading-edge sweep of 61°, and the new delta (triangular) shape with a leading-edge angle of 57°, so it was decided to build experimental versions of both. The single engine was Tuman-ski's AM-9B (later called RD-9B), as used in the twin-engined MiG-19, with a maximum afterburning thrust of 3,250kg (7,165 lb). The following specification refers to the swept-wing Ye-2, first flown on 14th February 1955. This led to the mixed-power Ye-50. The Ye-4, the first of the deltas, was very similar but had a disappointing performance. Despite this, with minor changes the delta Ye-5 was some 700km/h faster, leading to the production MiG-21. Even though all versions had limited capability, this small fighter was produced in four countries in greater numbers than any other military aircraft since 1945 apart from the MiG-15. Assuming 2,400 for Chinese production the total was 13,409.

| | | |
|--------------------------|--------------------|----------------------|
| Dimensions | | |
| Span | 8.109m | 26 ft 7/8 in |
| Length (excl pilot boom) | 13.23m | 43 ft 4 1/4 in |
| Wing area | 21.0m ² | 226ft ² |
| Weights | | |
| Empty | 3,687kg | 8,128lb |
| Internal fuel | 1,360kg | 2,998 lb |
| Loaded | 5,334kg | 11,759lb |
| Performance | | |
| Maximum speed | | |
| at 11,000m (36,089 ft) | 1,920km/h | 1,193 mph (Mach 1.8) |
| Service ceiling | 19,000m | 62,336ft |
| Range (estimated) | 1,220km | 758 miles |
| Take-off run | 700m | 2,297ft |
| Landing speed/ | 250km/h | 155 mph |
| run | 800m | 2,625 ft |

Ye-50

Right at the start of the 'Ye' programme Mikoyan had planned a mixed-power prototype, the Ye-1A, with the afterburning turbojet boosted by a Dushkin S-155 rocket engine. This was never built, but in 1954 it was re-stored to the programme with the designation Ye-50. One reason was the British Saro SR.53, with a similar propulsion system, and another was that the definitive RD-11 (later called R-11) engine was still some two years off. An order was received for three Ye-50 aircraft, and Ye-50/1 made its first flight (without using the rocket) on 9th January 1956, the same day as the first Ye-5. Though similar in size to the Ye-2 already described, the empty weight of the Ye-50/1 was 4,401kg (9,702 lb). This was because of the rocket engine and its tanks, an extended nose and additional equipment. The main engine was an RD-9Ye rated at 3,800kg (8,377 lb). The S-155 was fed with RFNA (red fuming nitric acid) and kerosene by a turbopump in the swollen base of the fin, driven by decomposing high-test hydrogen peroxide. The thrust chamber was immediately to the rear, above the main-engine afterburner. The whole rocket installation, though complex, was refined and reliable. On the turbojet alone this heavy aircraft was underpowered, and the bulk of the rocket and its tankage meant that with reduced jet fuel the range was very short. This aircraft was damaged beyond repair on its 18th flight on 14th July 1956. The Ye-50/2 reached 2,460km/h (1,529mph, Mach 2.32). The Ye-50/3 incorporated various modifications, but suffered inflight catastrophe, killing Nil pilot NA Korovin. Gor'kiy received a contract for a single Ye-50A with greatly increased rocket and jet fuel, made possible by a large tank scabbled on under the fuselage, but the Ministry decided against mixed-power aircraft (preferring much more powerful main engines) and the Ye-50A was never completed.

Ye-6/3T

The MJG-21F, the first series version, went into production at Gor'kiy in 1959. The factory designation was Ye-6/3T, and the third production aircraft, the 3T, was set aside to explore the effect of fitting canard (nose) foreplanes. These were small delta-shaped surfaces with cropped tips, the leading-edge angle being 45°. They were not powered but were pivoted on axes skewed at 40° and free

to align themselves with the local airflow. To prevent flutter a lead-filled rod projected ahead of the leading edge at mid-span. Their purpose was merely to reduce longitudinal static stability, but they were considered to be ineffectual in use.

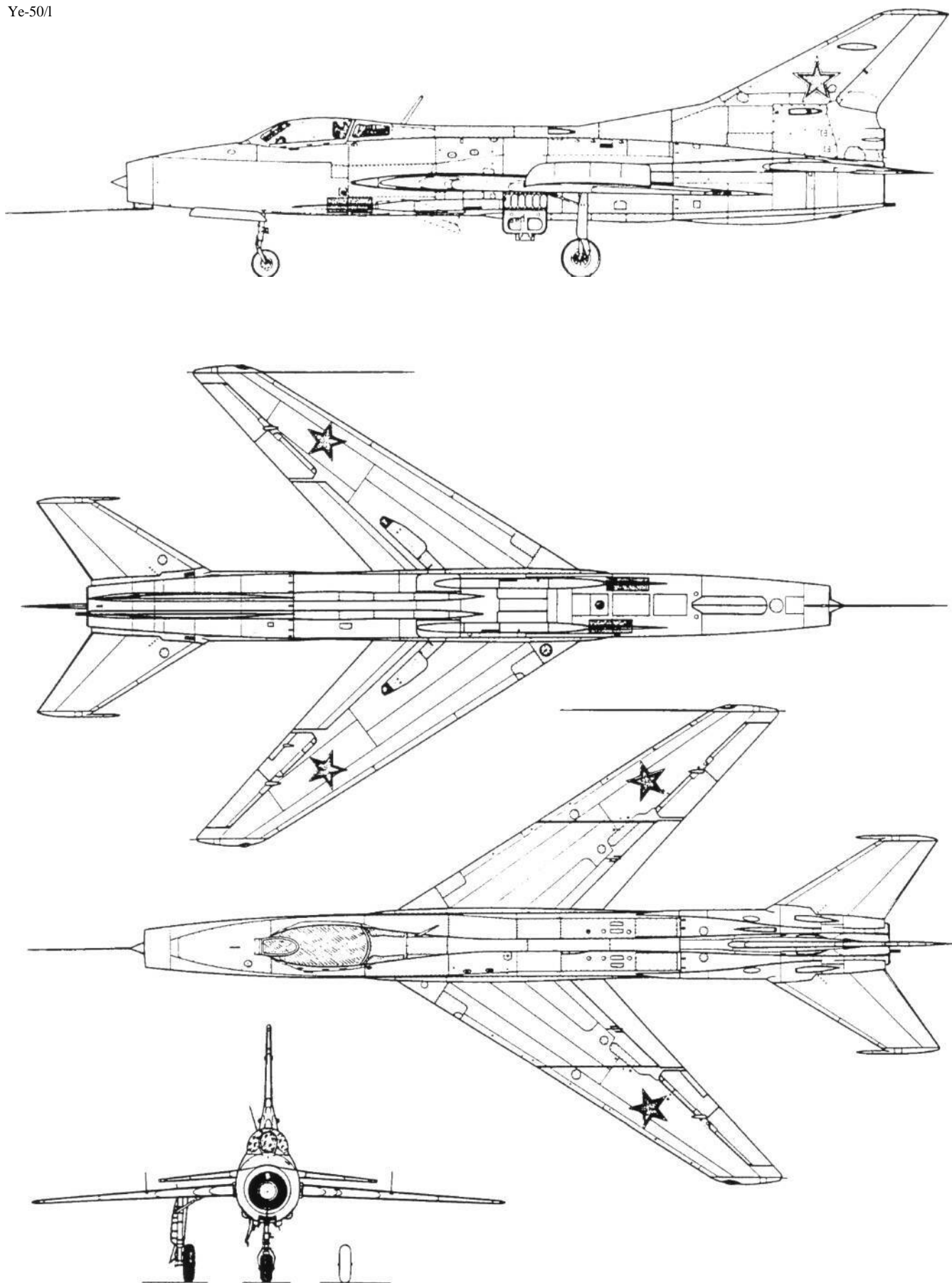
Ye-6T/1 (Ye-66A)

In 1960 the Ye-6T/1, the first true series-built MiG-21, call sign Red-31, was rebuilt for record purposes, with various modifications. In order not to reveal too much to the FAI international body, it was given the invented designation Ye-66A. The most obvious change was to attach a rocket package underneath the fuselage. The rocket engine was designated S-3/20M5A, the ultimate version of Dushkin's family burning kerosene and RFNA fed by peroxide turbopumps. The propellants were packaged with the engine and control system in a large gondola designated U-21. Thrust was 3,000kg (6,614 lb) at sea level, rising to about 3,700kg (8,150 lb) at high altitude. The rocket nozzle was angled 8° downwards, but despite this it was necessary to replace the usual MiG-21 underfin by two shorter but deeper ventral fins each inclined outwards. The main engine was replaced by an R-11F2-300, with a maximum afterburning rating of 6,120kg (13,492 lb); this engine later became standard on the MiG-21 PF. Other modifications included 170 litres (37.4 Imperial gallons) of extra kerosene fuel in a spine fairing behind the canopy, and a fin extended forwards to increase area of the vertical tail to 4.44m² (47.7ft²). The Ye-66A did not set any ratified speed records, but on 28th April 1961 it was flown by G K Mosolov in a zoom to a new world absolute height record of 34,714m (113,891ft). He made a low flypast with rocket in operation at the airshow at Moscow Tushino on Aviation Day (9th July) 1961.

MiG-21 PD, 23-31

Also designated MiG-21 PD, and known to the Mikoyan OKB as Izdeliye (product) 92, this was essentially a MiG-21 PFM fighter fitted with a lift-engine bay amidships. The early 1960s were a time when aircraft designers around the world were excited by the possibility of VTOL (vertical take-off and landing), which among other things enabled combat aircraft to avoid nuclear destruction by dispersing away from known airfields. Dassault put eight lift engines into the Mirage to create

Ye-50/1



the world's first Mach 2 VTOL. Mikoyan decided instead to build a STOL (short take-off and landing) MiG-21. The engine KB of P A Kolesov produced the simple RD-36-35, a lift turbojet rated at 2,350kg (5,181 lb). It would only have needed four of these to give the MiG-21 VTOL capability, but instead Mikoyan installed just two. The fuselage was removed between Frames 12 and 28A and replaced by a slightly widened fireproof bay housing the two lift engines. They were not pivoted but fixed at an inclination of 80°. Fuel was drawn from the (reduced) main tankage, and starting was by impingement jets using air bled from the R-11F2-300 main engine. The top of the bay was formed by a large louvred door hinged at the back. In STOL mode this door was pushed up by a hydraulic jack to provide unrestricted airflow to the lift engines. Each jet blasted down through a vectoring box. Made of heat-resistant steel, this provided seven curved vanes under each lift jet. These were pivoted and could be vectored by the pilot through an angular range of some $\pm 25^\circ$ to provide forward thrust or braking. The 23-31 was intended for exploring STOL, and for improved control at low airspeeds the main-engine bleed served reaction-control jets pointing down from under the nose and under each wingtip. The landing gears were fixed, and there was only one airbrake, of a new design, ahead of the lift-jet bay. Pyotr M Ostapenko made the first flight on 16th June 1966. He and BA Orlov both considered control at low airspeeds to be inadequate, and Ostapenko said 'For take-off you need maximum dry power on the main engine, but for landing you need full afterburner!' This aircraft performed briefly at the Moscow Domodedovo airshow on 9th July 1967. It was then grounded.

MiG-211 (2I-11)

This designation applied to two aircraft ordered from Mikoyan to assist development of the Tu-144 supersonic transport. They were also called MiG-211 (I for Imitator), and Analog. Both aircraft were taken from the assembly line of the MiG-21S, but were powered by a later engine, the R-13-300, rated at 6,490kg (14,308 lb). This engine could provide a large airflow for blown flaps, but as the Tu-144 (and thus the 2I-11) was a tailless delta no such flaps could be fitted. The wing was totally new, being of an ogival shape with the root chord extending over almost the entire length of the fuselage. The quite sharp leading edge had the remarkable sweep angle of 78°, before curving out to a sweep angle of 55° over the outer wings. There was no droop (downward camber) along the leading edge. On the

trailing edge of each wing were four fully powered surfaces, the inner pair being plain flaps and the outer pair elevons (surfaces acting as both elevators and ailerons). The wing was incredibly thin, thickness/chord ratio being only 2.3 per cent inboard and 2.5 at the tip. Thus, the control-surface power units were faired in underneath, the outer fairings extending over the entire chord of the wing. The wing leading edge was made detachable so that different shapes could be tested. Among other modifications was an increase in fuel capacity to 3,270 litres (719 Imperial gallons), and of course there was no provision for armament. Partly because of a 'chicken and egg' situation, in which Mikoyan was uncertain precisely what shape to make the wing, whilst the purpose of the Analog was to teach Tupolev how to design the Tu-144's wing, the programme ran at least a year too late to assist the design of the SST. Eventually O VGudkov flew 23-11/1 on 18th April 1968, with civil registration SSSR-1966, the intended first-flight year. The Tu-144 pilots flew this aircraft before first flying the 44-00 (first Tu-144) on 31st December 1968, with the 23-11/1 accompanying it as chase aircraft. The 23-11/2 differed mainly in that all eight wing movable surfaces were elevons. It was first flown by I Volk in late 1969. Later its starboard wing upper surface was tufted, photographed by a camera on the fin (later a second camera was added looking back from behind the canopy). Most of the second aircraft's flying was done with a large LERX (leading-edge root extension) giving increased area from the new curved front portion. The 2I-11/2 carried out extensive aerodynamic and control research before going to the WS Museum at Monino. The 2I-11/1 was crashed on 28th July 1970 by an LII pilot performing unauthorised low-level aerobatics. Mikoyan did not act on the suggestion of the main 23-11 test pilots that he should develop a fighter version.

Ye-8

So different in appearance as hardly to be considered a MiG-21 version, these two aircraft were considered as prototypes of a possible improved fighter. They resulted from a Kremlin decree of spring 1961 calling for 'a version of the MiG-21 capable of destroying hostile aircraft at night or in bad weather'. This was intended to become the MiG-23. The key feature was use of the Volkov KB's Sapphir 21 (Sapphire) radar. This was far too bulky to fit inside any possible MiG-21 nosecone, and the answer was to feed the engine by a completely new inlet under the fuselage. There was an advantage in doing this in that the inlet could be given variable geometry with mov-

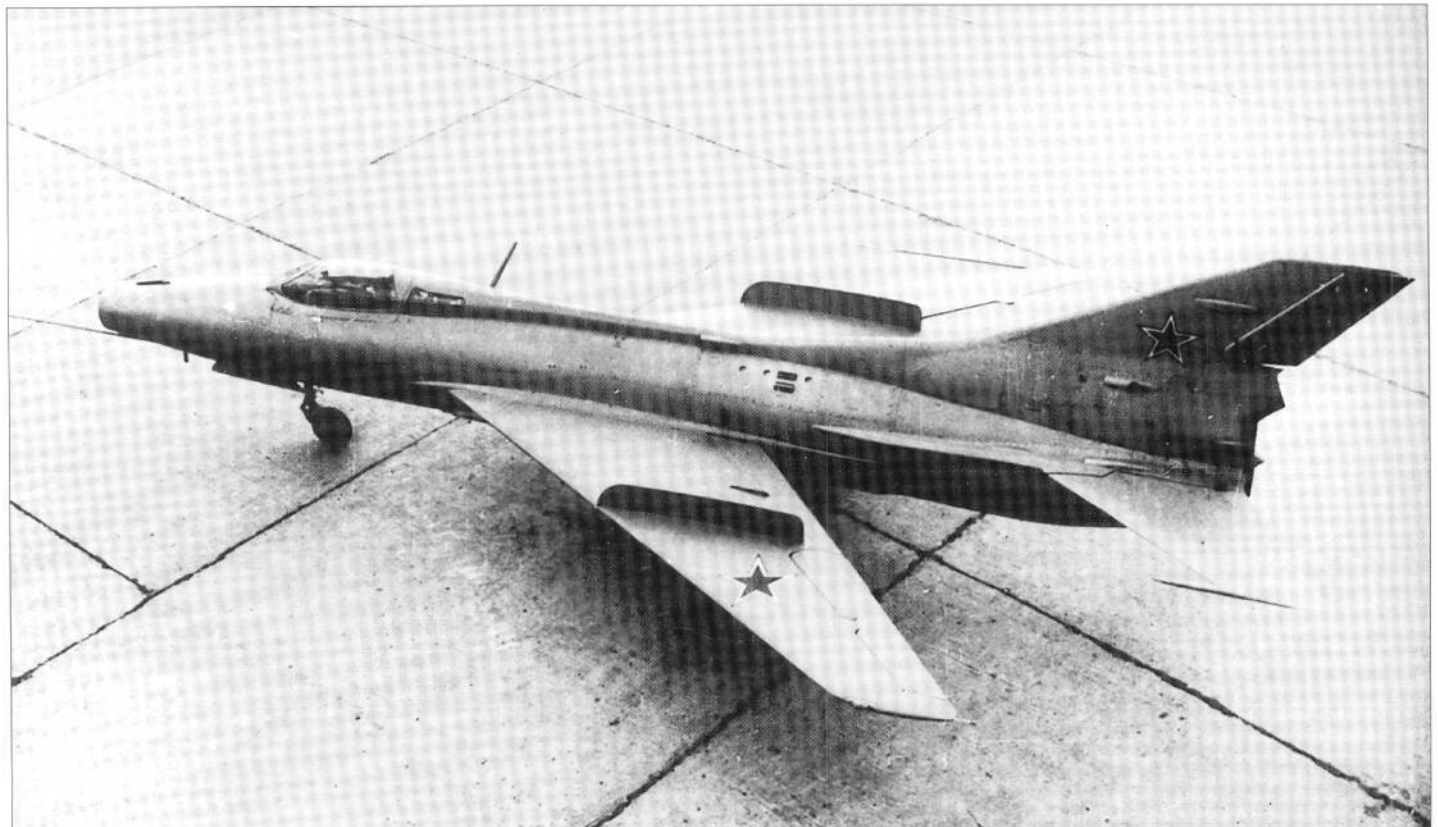
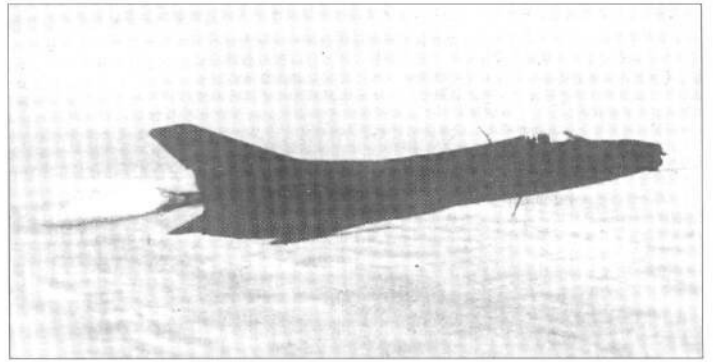
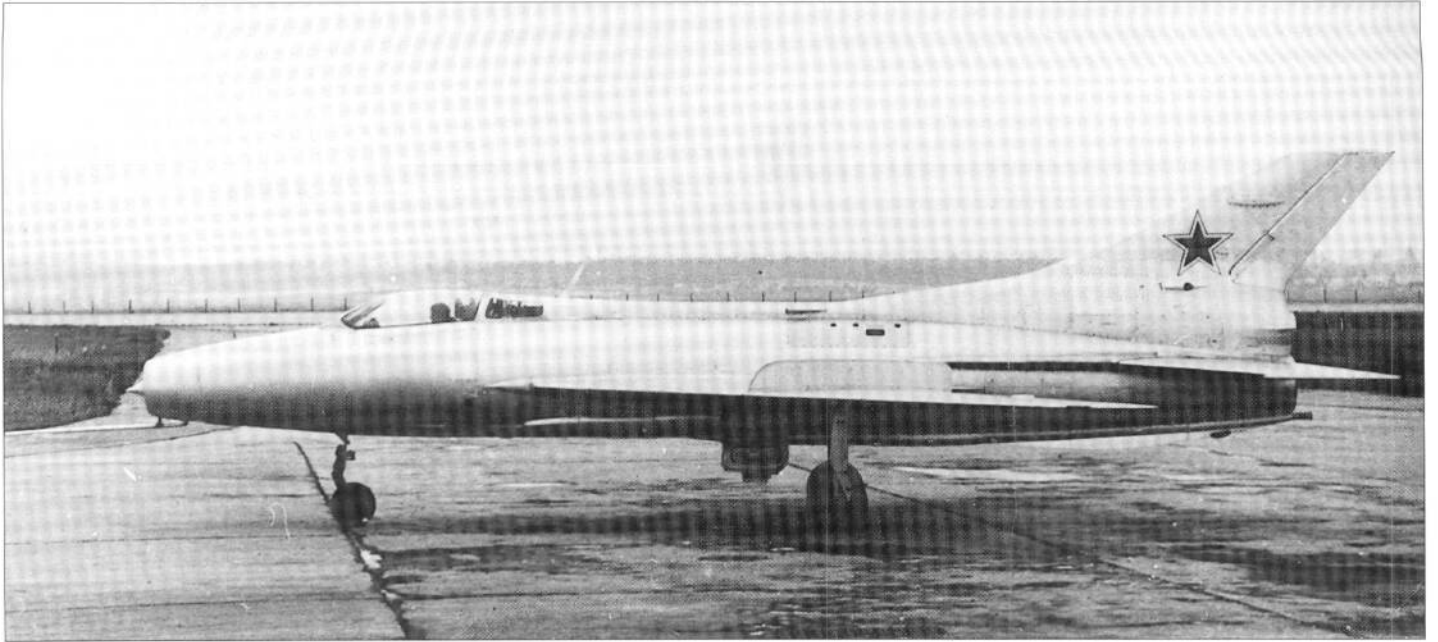
able walls, and auxiliary inlets under the wing leading edge. On each side of the nose, just behind the radar, was a canard foreplane of cropped delta shape, with anti-flutter rods similar to those of the Ye-6T/3. Normally free to align themselves with the airflow, at Mach numbers in excess of 1.00 they were locked at zero incidence. The effect was dramatic: at 15,000m (49,200ft) they enabled the acceleration in a sustained turn to be increased from 2.5 g to 5.1 g, and they gave significantly enhanced lift in all flight regimes. Other modifications included a slightly lowered horizontal tail and a large underfin which was folded to starboard when the landing gear was extended. All might have been well had not the design team elected also to exchange the R-11 engine for the immature R-21, from the Met-skharishvili KB, with afterburning rating of 7,200kg (15,873 lb). Ye-8/1 was flown by Mosolov on 5th March 1962, and destroyed on 11th September by catastrophic failure of the engine. Ye-8/2, which had blown flaps, first flew on 29th June 1962 but suffered so many engine faults this otherwise promising aircraft was abandoned.

Photographs on the opposite page:

Top and centre left: Two views of Ye-50-1.

Centre right: Ye-50-2 with rocket engine in action.

Bottom: Ye-50-3.





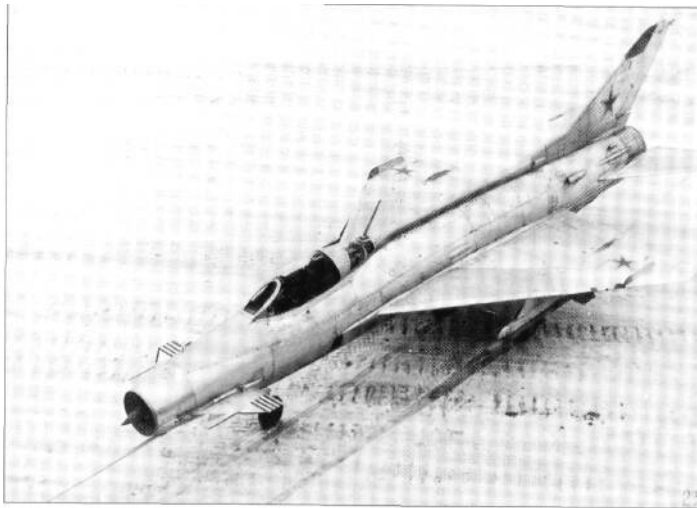
Left: Drawing of Ye-50A.

Below left: Ye-6/3T.

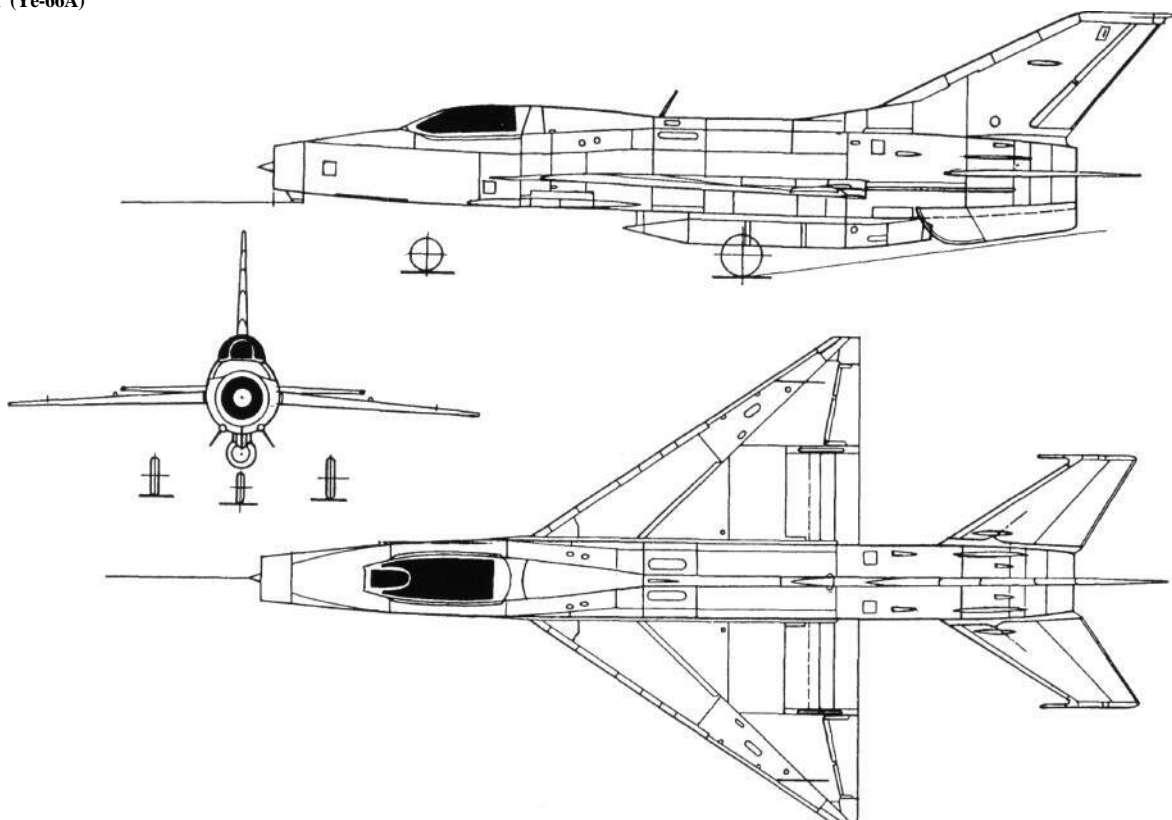
Below right: Ye-6T/1 (Ye-66A).

Photograph on the opposite page:

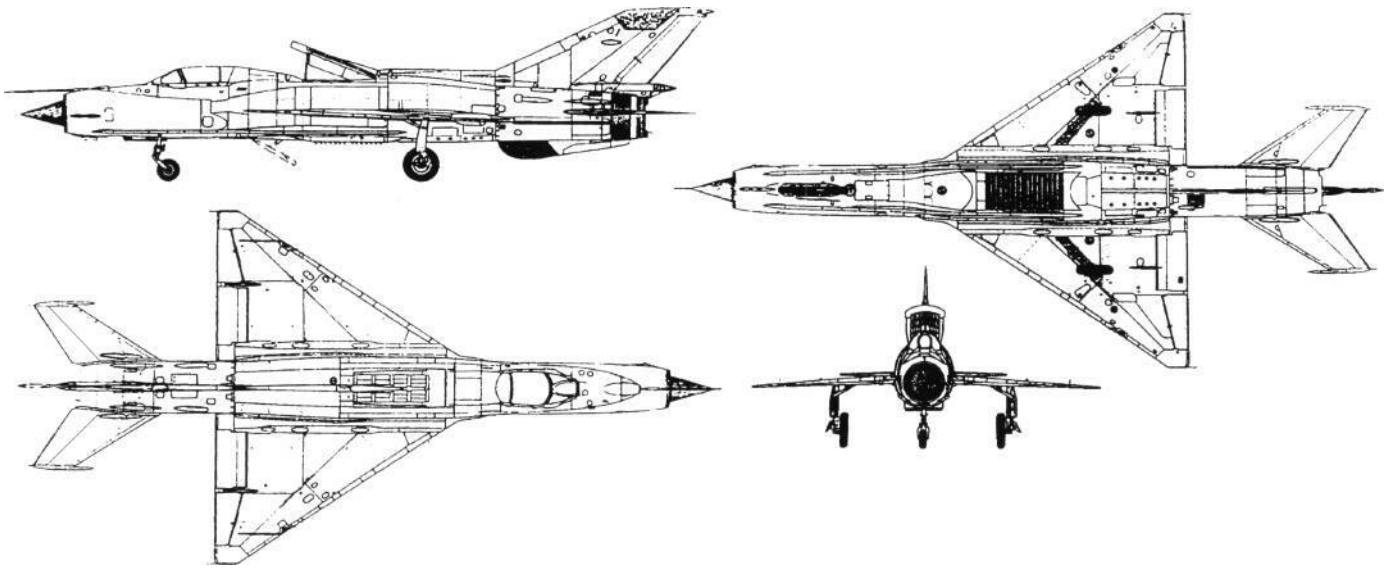
MiG-21 PD (23-31).



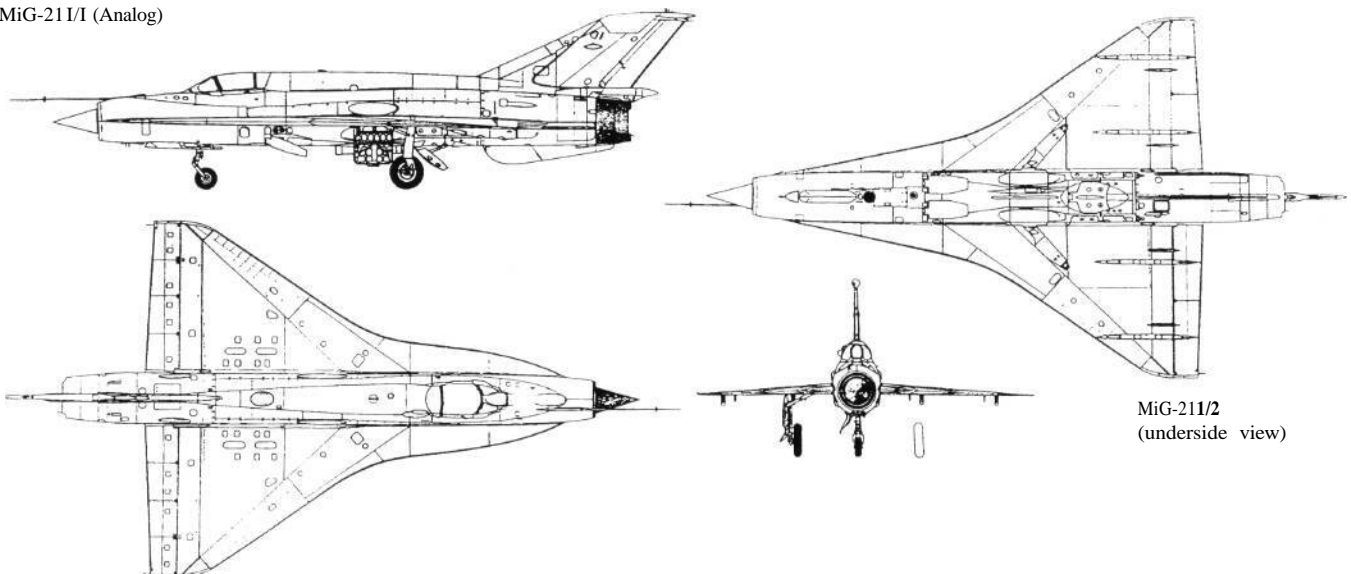
Ye-6T/1 (Ye-66A)



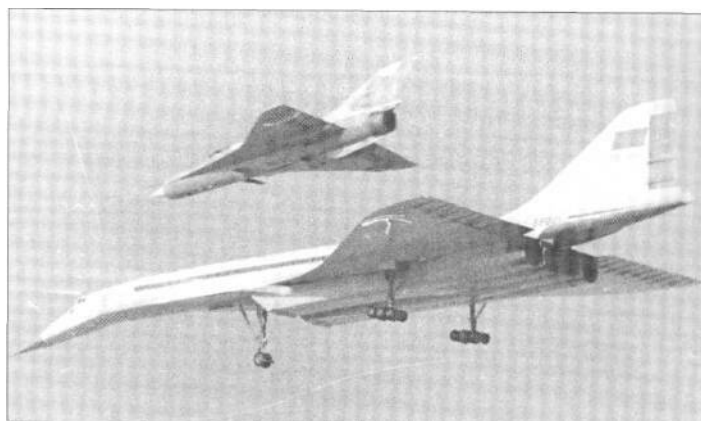
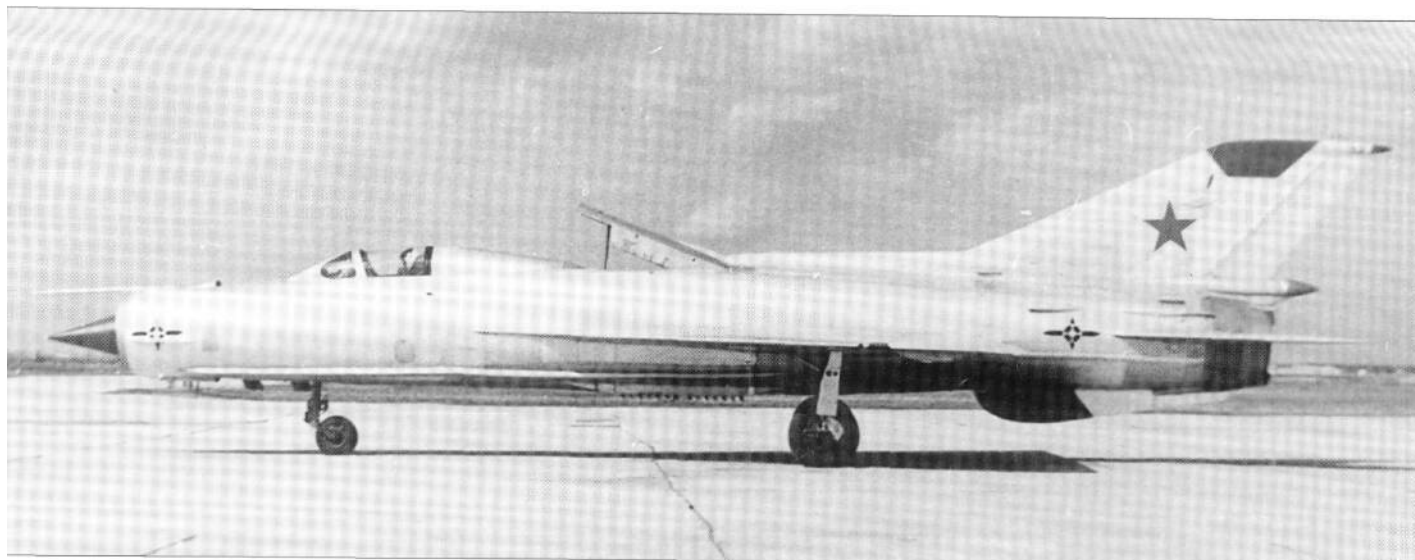
MiG-21PD(23-31)

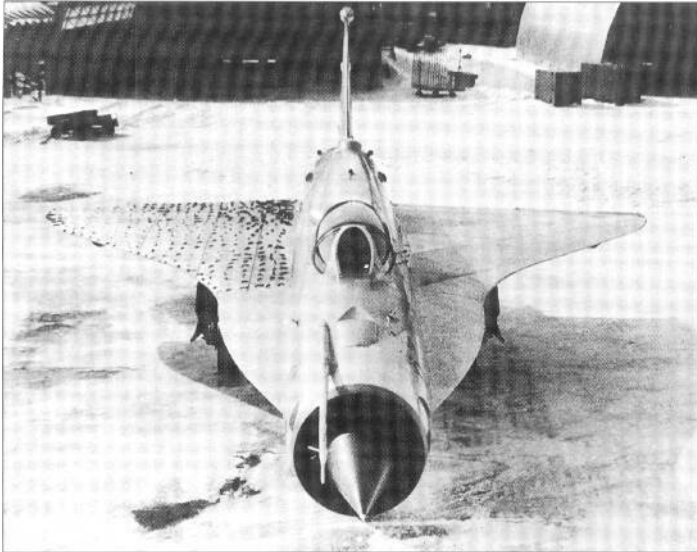


MiG-211/I (Analog)



MiG-211/2
(underside view)





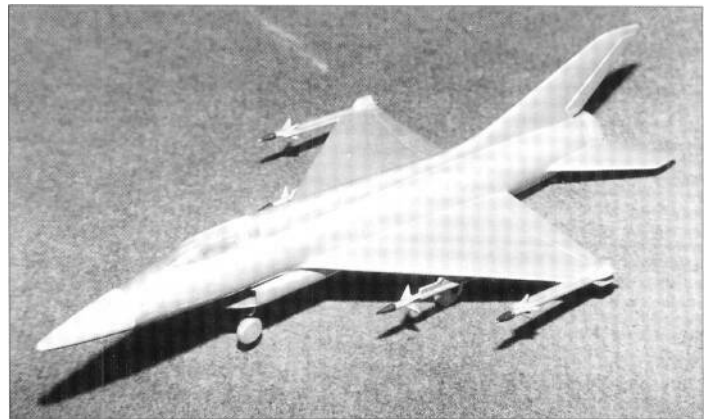
Photographs on the opposite page:

Top: MiG-21PD(23-31).

Centre left: MiG-211/1 **with 44-00** (first prototype Tu-144).

Centre right: MiG-211/1.

Bottom: MiG-21 PD (23-31) **at Domodedovo Air Parade, July 1967.**



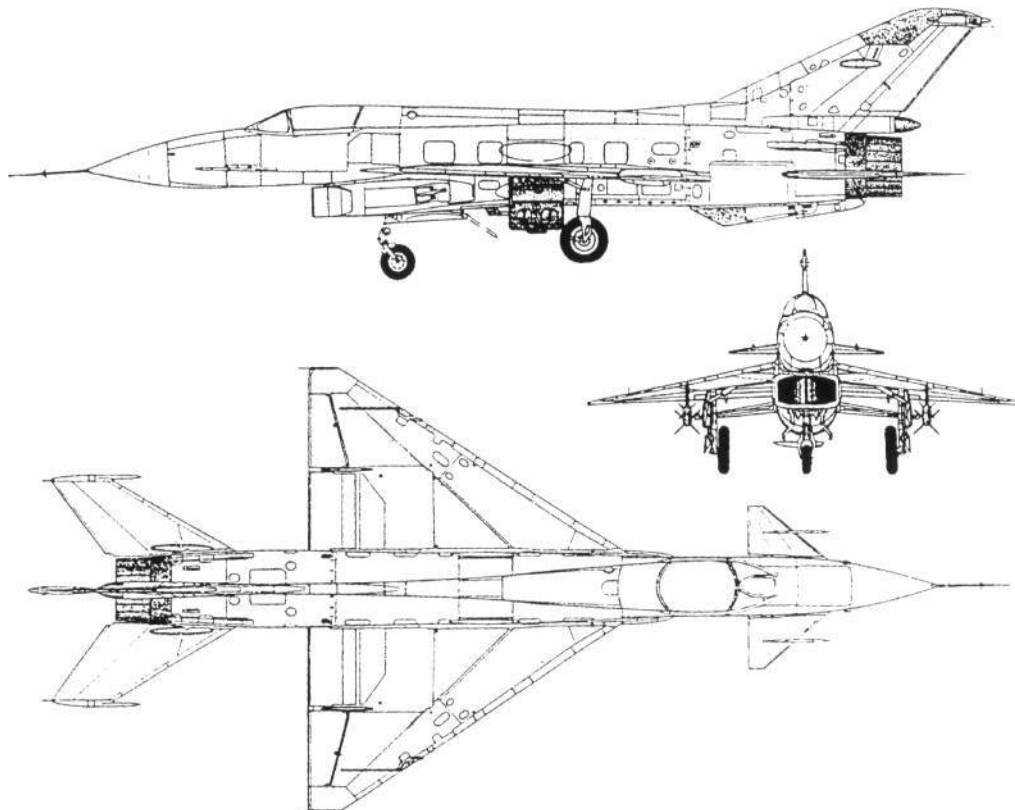
Photographs on this page:

Top left: MiG-211/2 **with one wing** tufted.

Top right: Ye-8/2.

Right: Model **of** Ye-8 interceptor project.

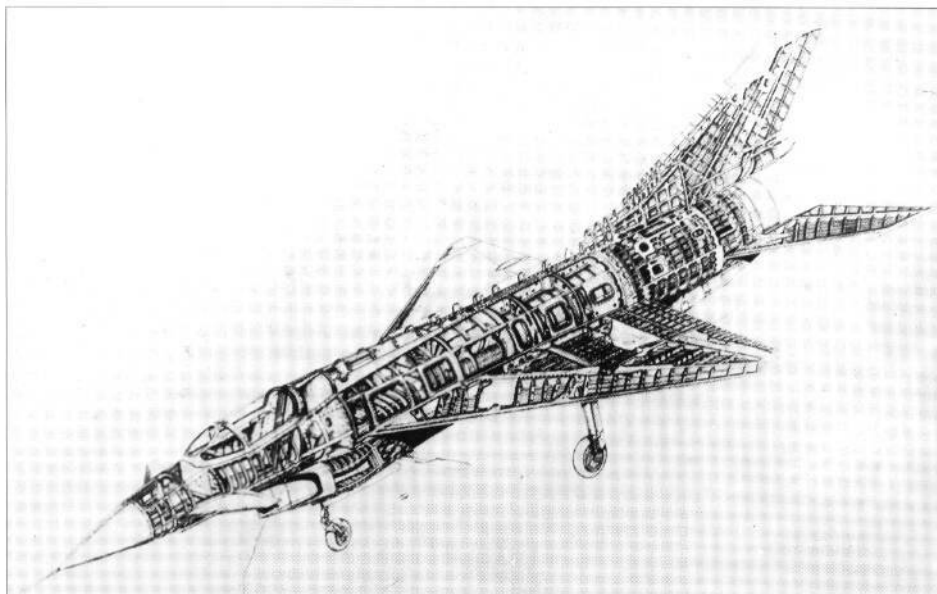
Ye-8





Above left and right: Two views of Ye-8/2.

Left: Ye-8 cutaway.



1VKG-23PD, 23-01

Purpose: To evaluate a STOL fighter larger than the MiG-21.

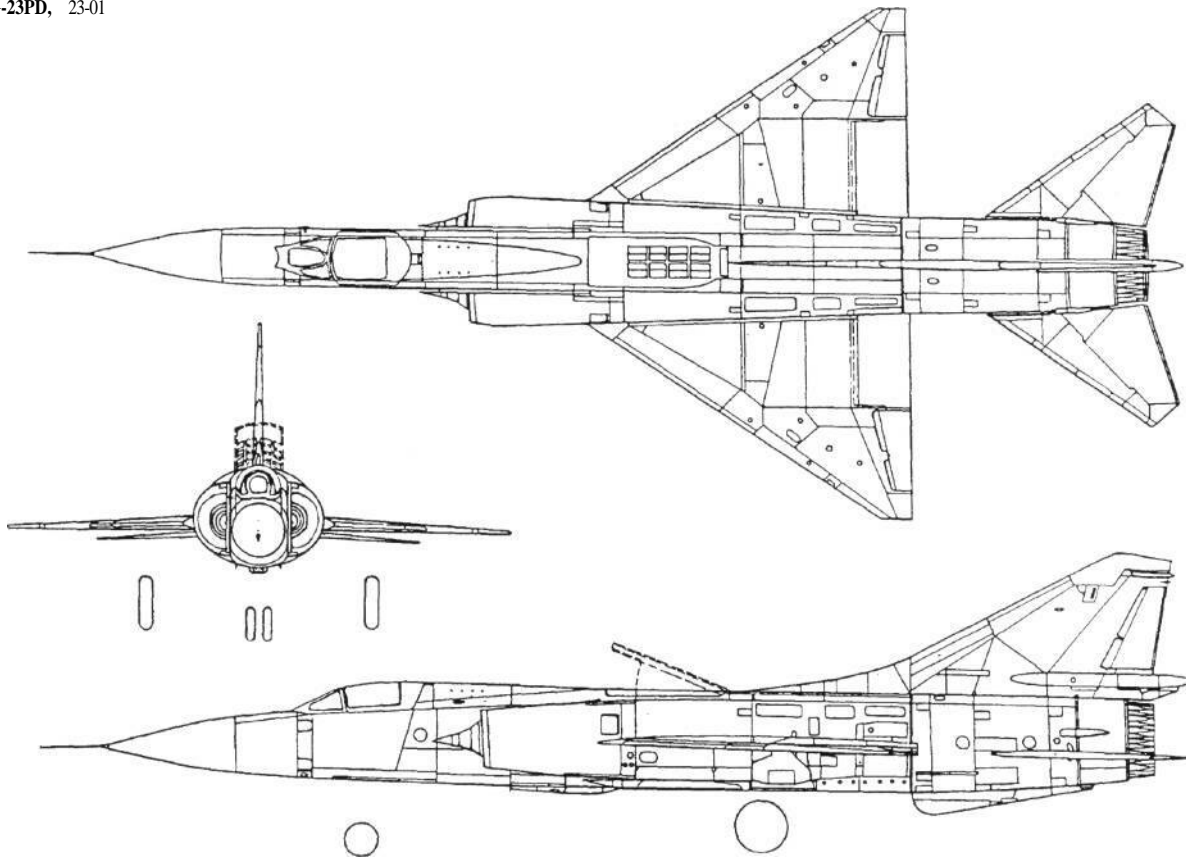
Design Bureau: OKB-155 of A I Mikoyan.

By the 1960s, though the MiG-21 was going from strength to strength, the family of so-called heavy interceptors were being overtaken by the Ye-155 project (which became the MiG-25), and, by now facing severe competition from Sukhoi, there was an urgent need for a new tactical family more capable than the MiG-21. The new engine KB of K Khachaturov had produced an outstanding new engine, the R-27-300 (as before, the suffix -300 signified Factory No 300), an afterburning turbojet with maximum thrust of 7,800kg (17,196lb). This was intermediate between MiG-21 engines and those of the big interceptors. Mikoyan began studying future prospects for this engine in 1960. In 1964 he obtained an order for the 23-01 with a delta wing and a lift-engine bay, and in 1965 he was ordered to build the competing 23-11 with no

lift engines but a variable-geometry 'swing wing'. Even though the 23-01 was managed by V A Mikoyan, second son of the General Constructor's brother Anastas, President of the Supreme Soviet, it was considered in the OKB (correctly, as it turned out) to be a waste of time. This was because of the American fixation on the VG wing for the F-111. Despite this, the 23-01 was the subject of meticulous effort. The wing was like a scaled-up version of the blown-flap MiG-21, almost as large as a Ye-152, but with different main landing gear geometry. The tailplanes were of a new design, with sharp taper (almost becoming delta shape) and tips cropped at the Mach angle. The fuselage was totally new, with a nose designed to accommodate a powerful radar fire-control system (not fitted), lateral inlets with sliding centrebodies for the main engine, and a lift-engine bay between the main-engine ducts almost identical to that of the 23-31. The two RD-36-35 lift turbojets had a combined thrust of only 4,700kg (10,362lb),

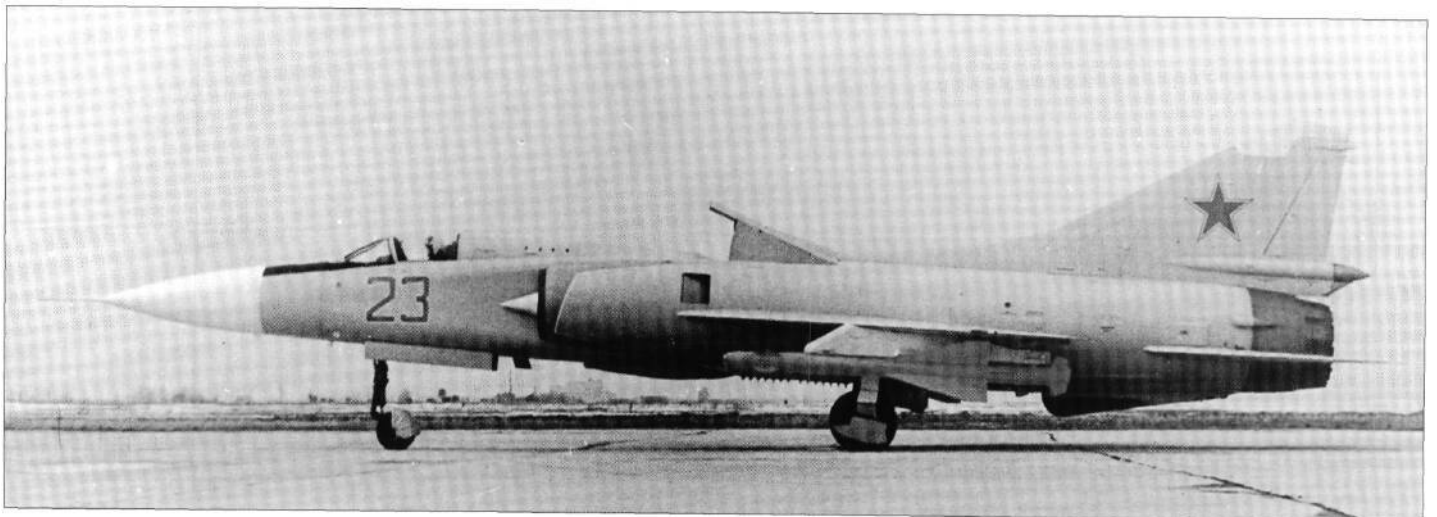
and as this was a mere 29.5 per cent of the gross weight the 23-01 was never flown slower than 150km/h (93mph). Thus, it was not fitted with reaction-control jets. The landing gears were new, the large KT-133 mainwheels being housed upright in the sides of the fuselage and the nose unit having twin wheels, power steering and retracting not forwards but backwards. The KN-type seat was installed in a cockpit similar to that of contemporary MiG-21s. Ostapenko began the brief factory test programme on 3rd April 1967. He was soon joined by Fedotov, but long before the 23-01 was completed Mikoyan had ceased to be interested in liftjets. With one eye on disinformation the number **23** was painted on the fuselage, an inoperative GSh-23L gun was fitted, and dummy Vympel R-23R and R-23T missiles were hung under the wings. The 23-01 was then briefly demonstrated at the big airshow at Moscow Domodedovo on 9th July 1967.

MJG-23PD, 23-01



| Dimensions | | |
|------------------------------|--------------------|----------------------|
| Span | 7.72m | 25 ft <i>m</i> in |
| Length (excl PVD boom) | 16.8m | 55 ft 1 1/2 in |
| Wing area | 40.0m ² | 430.6ft ² |
| Weights | | |
| Empty | 12,020kg | 26,500 lb |
| Loaded | 16,000kg | 35,273 lb |
| Performance | | |
| Take-off run (light) | 1 80-200 m | 591-656 ft |
| Landing run (with parabrake) | 250 m | 820 ft |

Two views of 23-01, with dummy R-23 guided missiles.



MiG 105-11

Purpose: To investigate the low-speed handling within the atmosphere of an orbital shape.

Design Bureau: OKB-155 of AI Mikoyan.

By 1965 the Mikoyan OKB was deeply into the technology of reusable aero-space vehicles. Under 'oldest inhabitant' GYe Lozino-Lozinskiy a shape was worked out called BOR (from Russian for pilotless orbital rocket aircraft), and in turn this was the basis for the manned Epos (an epic tale). The BOR test vehicles had been fired by rocket and recovered by parachute, but a manned vehicle had to land in the conventional way. It was considered prudent to build a manned test vehicle to explore low-speed handling and landing. Called 105-11, -12 and -13, only the first is believed to have flown. The OKB pilot was Aviard Fastovets, and he began high-speed taxi tests at Zhukovskii in September 1976. On 11th October 1976 he took off and climbed straight ahead to 560m (1,837ft). He landed as planned at an airfield about 19km (12 miles) ahead. On 27th November 1977 he entered 105-11 slung under the Mikoyan OKB's Tu-95K

(previously used for cruise-missile tests) and landed on an unpaved strip after release at 5,000m (16,400ft). The 105-11 made seven further flights, the last in September 1978. It was then retired to the Monino museum.

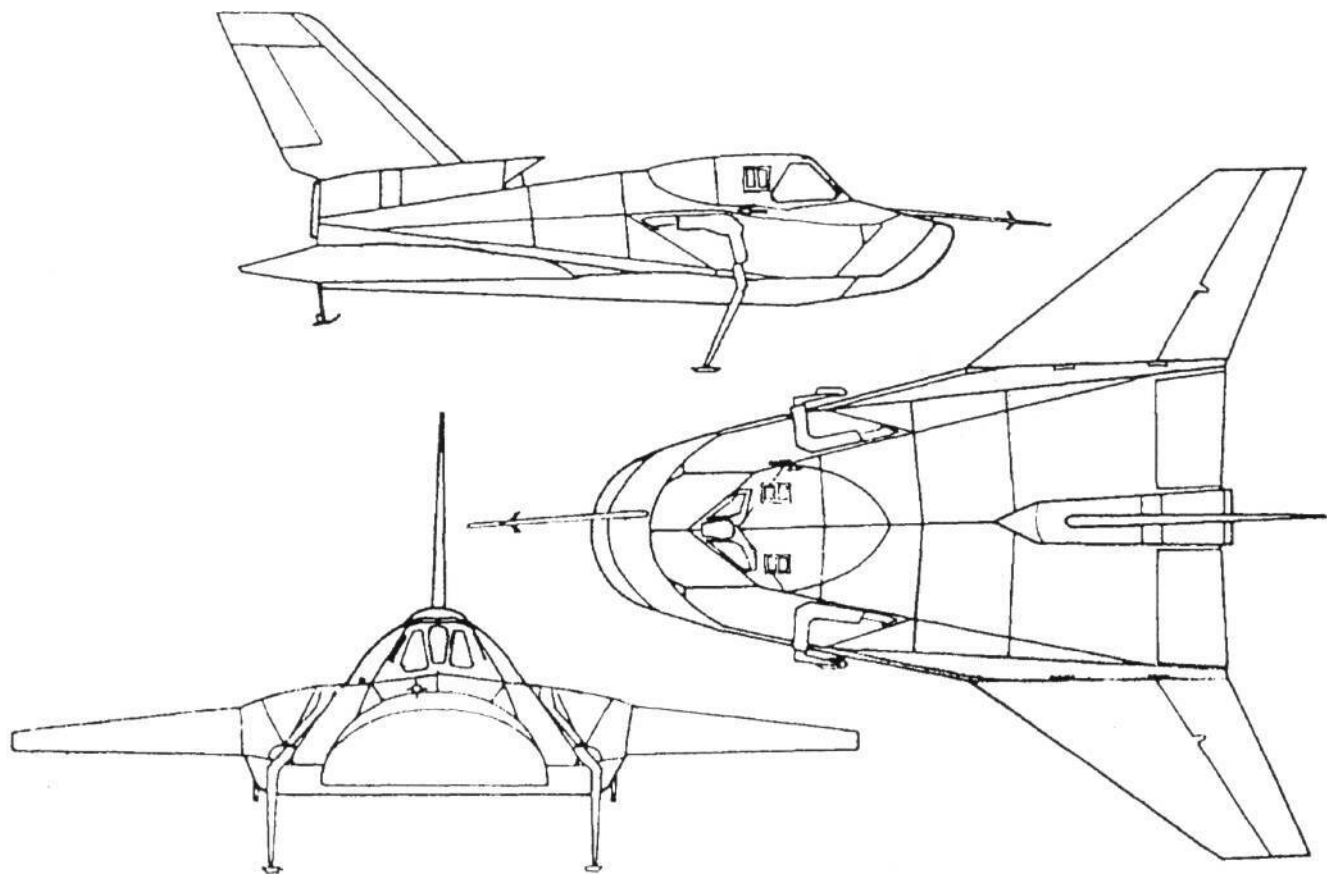
The 105-11 was almost the size of a MiG-21, and was likewise a single-jet tailless delta. The fuselage had a broad 'waverider' shape, with a flat underside, and the cockpit at the front was entered via a roof hatch. From the sides projected small swept wings with elevons, and there was a large fin and rudder. The engine was an RD-36-35K turbojet derived from the previously used lift engines, rated at 2,000kg (4,409 lb). It was fed by a dorsal inlet with an upward-hinged door to fair the engine in when in high-speed gliding flight. Features of the eventual hypersonic Epos included a flat unfaired tail end to the broad fuselage, the upper surface comprising large upward-hinged airbrakes, and a structure designed to accommodate severe thermal gradients, though the 105-11 was never designed to fly faster than Mach 0.8. Early testing was done with rubber-tyred wheels on the front two retractable legs and steel skis on

the rear pair (the OKB record that the runway was lubricated by crushed melons). For the air-drop tests all four legs had steel skids.

The brief flights of the 105-11 confirmed the design of a manned aero-space vehicle, leading to the Buran (see later).

| Dimensions | | |
|---|--------------|--------------|
| Span | 6.7m | 21 ft 11½ in |
| Length (excluding multi-vane PVD instrument boom) | 10.6m | 34ft9¾/3in |
| Area of wing and lifting body | 24.0m² | 258ft² |
| Weights | | |
| Empty | 3,500kg | 7,716 lb |
| Fuel | 500kg | 1,102 lb |
| Loaded | 4,220kg | 9,300 lb |
| Performance | | |
| Maximum speed (design) | Mach 0.8 | |
| (actually reached) about | 800km/h | 500 mph |
| Landing speed | 250-270 km/h | 155-168 mph |

105-11, with skids





Above left and right: Two views of 105-11.



Left: 105-11, with skids, preserved at Monino.

MiG 1.44

Purpose: Technology test-bed to support the 1.42 multirole fighter.

Design Bureau: ANPK (Aviatsionnyi Nauchno-Promishlennyyi Kompleks) MiG, now the main design unit of RSK 'MiG'.

In 1983 the large and powerful MiG OKB began general parametric study of an MFI (Mnogofunktsional'nyi Frontovoi Istrebitel, multirole tactical fighter). This was to be a totally new aircraft as ahead of global competition as the MiG-29 had been. It was to be larger than the MiG-29, to serve as a successor to the long-range MiG-31 and MiG-31M interceptors, but also with the supermanoeuvrability needed for close combat and the ability to fly air-to-ground missions as well. In 1986 the Council of Ministers issued a directive ordering MiG, Sukhoi and Yakovlev to make proposals for a 'fifth-generation' fighter to counter the threat posed by the USAF's Advanced Tactical Fighter, which later led to the F-22A Raptor. The WS called the requirement I-90 (Istrebitel, fighter, for the 1990s). The MiG project staff eventually settled on two configurations, called Izdelye (product) 1.41 and 1.43. After prolonged discussion with the WS, features of both were combined in the 1.42. In late 1986 contracts were placed for a static-test airframe, a dynamic and fatigue-test airframe and two flight articles, as well as for the totally new AL-41F engine,

N-014 radar and various special test rigs. Supervised by General Constructor Rostislav Apollosovich Belyakov, detailed design proceeded under Chief Project Engineer Grigori Sedov, later succeeded by Yuriy Vorotnikov. So great was the designers' faith in the 1.42 that complete manufacturing documentation and software was completed at an early stage. Largely computerised manufacturing began at the Mikoyan experimental shop in 1989. The first flight article, designated 1.44, is a simplified technology demonstrator to prove the aerodynamics and flying qualities, performance and propulsion. Compared with the 1.42 it has an almost pure delta wing (instead of a cranked leading edge) and a slightly different air inlet system, and lacks the radar, mission avionics and internal weapons bay. By 1991 the 1.44 was structurally complete, but was awaiting flight-cleared engines, the agregat (accessory gearbox) and several other components. By this time collapse of the Soviet Union had begun to cut off funding and seriously delay the programme. The original first-flight date of 1991-92 was forgotten, but in December 1994 the 1.44 was completed and brought by road to the OKB's flight-test facility at the Zhukovskii NII-WS (air force flight-test institute). On 15th December 1994 Roman Taskaev, then Chief Test Pilot, began fast taxiing trials. Though several crucial elements had not been cleared for

flight it was hoped to display the aircraft 'Blue 01' at the MAKS 1995 show in August 1995. However, in May 1995 the hope of imminent flight trials was dashed when ANPK MiG became part of MAPO, whose sole interest was producing aircraft, such as the MiG-29 and various other types (by no means all of MiG design) to raise money. Things changed in September 1997, when Sukhoi flew the rival S-37 and Mikhail Korzhuyev was appointed ANPK MiG's General Director. He was determined not to let this rival, and possible link to the next generation, languish in its hangar any longer. In December 1995 he got the WS to declassify photographs taken on first rollout in 1994. He then obtained permission for guests, including Defence Minister Igor Sergeyev, to walk round the 1.44 on 12th January 1999. On that occasion the aircraft rolled out under its own power (with astonishing quietness), Vladimir Gorboonov in the cockpit. At least one observer was impressed, Air Force/Air-Defence Force C-in-CCol-Gen Anatoliy Kornokov saying 'This aircraft can do everything you want it to'. Gorboonov began the much-delayed flight-test programme on 15 February 2000, Korzhuyev saying 'We can make the first five or six flights without external financing'.

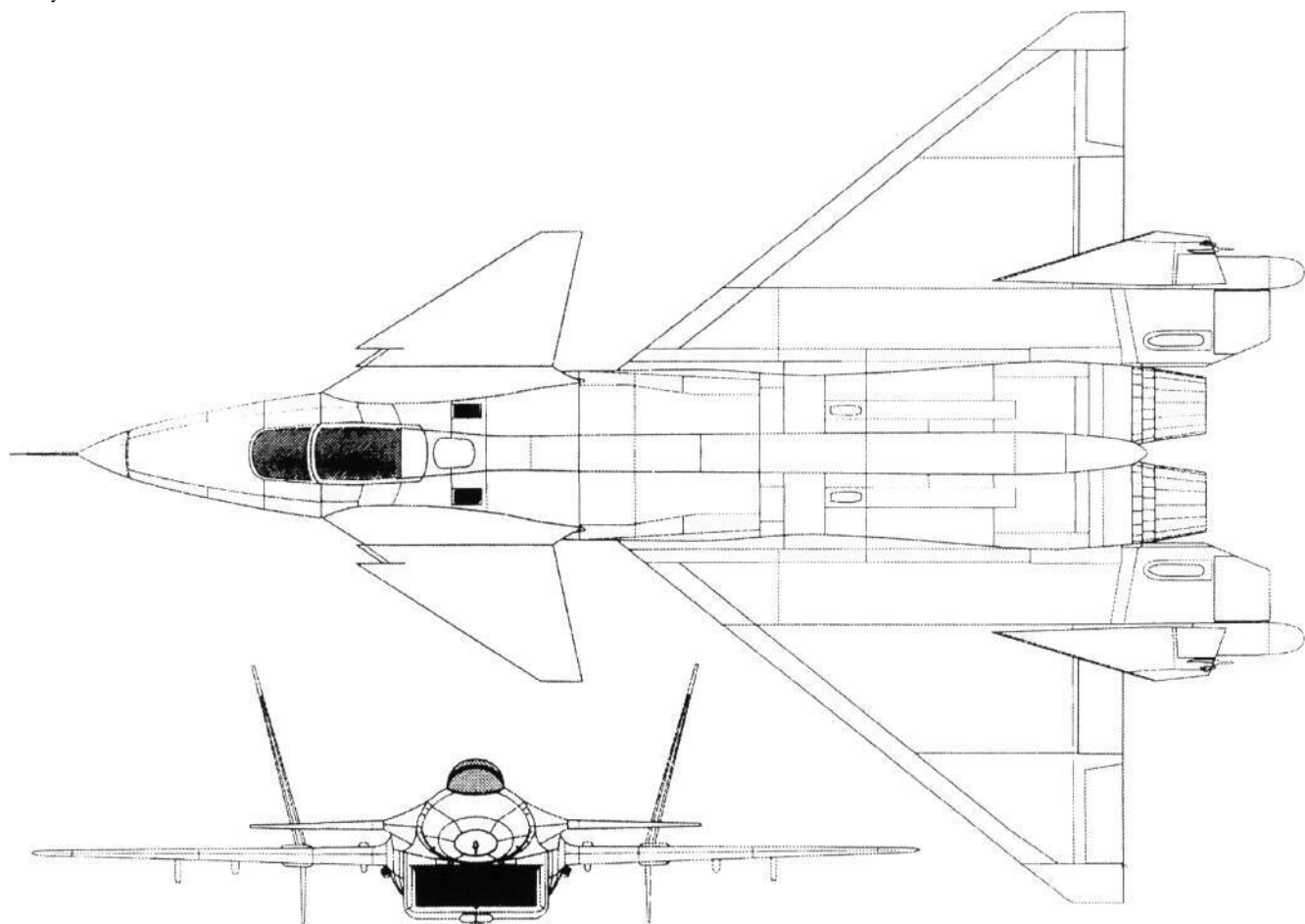
The 1.44 is an extremely large single-seater, designed to fly significantly faster than any aircraft it might encounter. Each wing is an al-

most pure cropped delta with a thickness/chord ratio of about 3.5 per cent and leading-edge angle of about 48° (50° over the innermost section). On the leading edge are almost full-span hinged flaps, while on the trailing edge are large inboard and outboard flaperons driven by power units in underwing fairings. Unlike the MiG-29, the wing is not blended into the fuselage, nor does it have a LERX (leading-edge root extension). As far forward as possible without interfering with pilot view are enormous canard foreplanes, driven over a large angular range. Each has a sharp dogtooth, and a second smaller dogtooth due to the fact that these are 1.42 canards which do not perfectly match the large bulging fixed roots of the 1.44. Like the MiG-29 a structural beam projects behind each wing to carry the outward-sloping upper fins, but these beams are much further apart. Thus, there is now a wide space between the beam and the adjacent engine, and in this is placed a secondary elevator, driven by a powerful actuator in a projecting fairing. Each fin has an inset rudder, and under the beams are vertical underpins with powered rudders. The

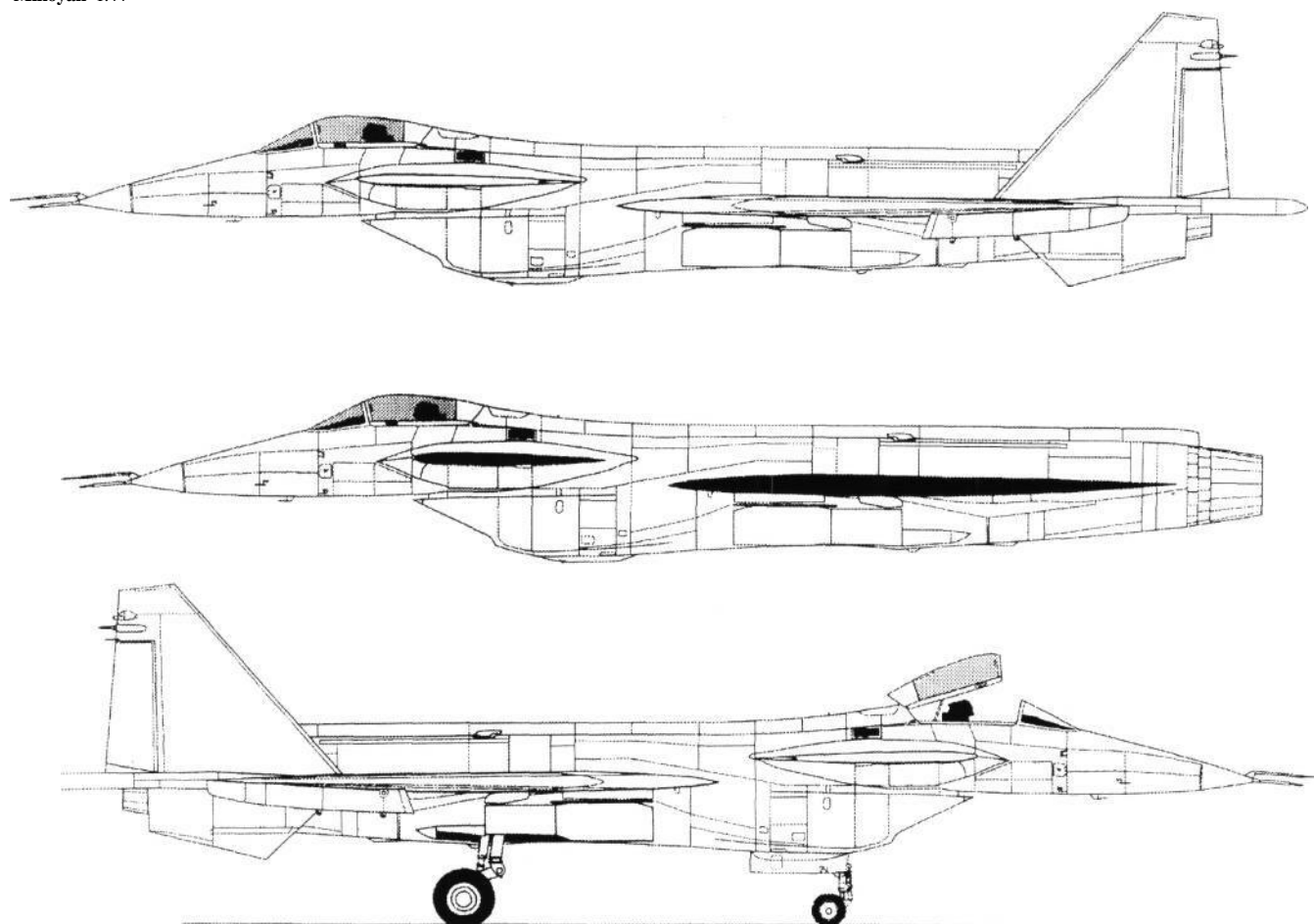
basic aircraft is designed to be longitudinally unstable and to fight at alphas (angles of attack) up to at least 100° , which explains the unprecedented 16 flight-control surfaces. These are needed because, unlike the F-22 (say Mikoyan) the basic aircraft is designed for close air combat. At high alphas powerful lift is generated by the canards and by the flat nose and huge flat underside of the fuselage. Absence of LERXs means that, instead of there being an inlet under each wing, there is a single giant rectangular inlet a considerable distance below the forward fuselage. In view of the high design Mach number, the upper wall is fully variable, the sides are cut sharply back in side view, and the lower lip hinges down in high-alpha flight. The ducts diverge immediately to pass the nose gear, and then rise over the weapons bay (in this prototype occupied by instrumentation). The faces of the engines cannot be seen externally. The Saturn (Lyul'ka) AL-41F augmented turbofans are quite close together. Prototype engines were made available because, unlike the S-37, the Mikoyan aircraft is the official choice as the next-generation fighter. Dry

and maximum ratings are approximately 12,000kg (26,455 lb) and 20,000kg (44,090 lb). This engine, said General Designer Dr Viktor Chepkin, was designed for 'the new tactical fighters of the 1990s'. In 1993 he told co-author Gunston that the dry weight of the AL-41F is 'about the same as that of the previous-generation engines with half the power', the actual T/W (thrust:weight ratio) being 11.1 compared with 8 for the AL-31F. On the public rollout of the 1.44 the engines were astonishingly quiet. By 1997 a total of 27 AL-41 and AL-41F engines had run, and extensive flight testing had taken place under a Tu-16 and in the left position of a MiG-25. T/W ratio of the clean aircraft is no less than about 1.33. The nozzles are circular, with petals giving a variable convergent/divergent profile, their inner faces being coated with a tan-coloured ceramic. Each nozzle can be vectored over limits of $\pm 15^\circ$ vertically and $\pm 8^\circ$ horizontally. In the nose is a forked pair of pilot tubes. The canopy swings up and back on four parallel arms. Above the huge wing the fuselage has visible waisting, and the broad but shallow central spine (which can readily be enlarged

Mikoyan 1.44



Mikoyan 1.44



if necessary) terminates in a capacious bay for a braking parachute. The landing gears all have levered trailing-link suspension, the single-wheel main units swinging forward into compartments beside the 'weapons bay' and the steerable twin-wheel nose unit retracting backwards to lie between the ducts. There is no problem with nosewheel slush entering the ducts, the height of the landing gears being dictated by landing attitude. Though Blue 01 has the full Avionika KSU-I-42 digital control system, which interlinks all the flight controls and engine nozzles, it does not have the intended Fazotron N-014 (beetle) multi-mode radar nor the aft-facing radar and countermeasures which in the 1.42 would occupy the two tailcones. In an armed aircraft provision would be made for a heavy load of weapons internally and on wing pylons (the 1.44 has hardpoints for six), and also for a 30mm gun. Dielectric flush antennas face in all directions, though in the 1.44 many are empty. The 1.44 lacks a RAM (radar-absorbent material) coating, but Mikoyan claim the RCS (radar cross-section) of the MFI would be 'similar to that of the smaller F-22'.

Had the MFI progressed according to its

original schedule it could well have been, if not a world-beater, at least a formidable rival to the much slower F-22. As it is, unless ANPK MiG can find a rich foreign partner, it could gradually be overtaken by foreign competitors. In any case, the days when MiGs sold partly because of their low price are over. Several analysts consider that a production MFI would have to be priced at not less than US\$100 million. Indeed, Korzhuyev has gone so far as to suggest that, instead of being one step away from a production MFI, the 1.44 must be regarded as 'a flying laboratory to assist the development of a new fighter that will be smaller and cheaper'.

| Dimensions (estimated) | | |
|-------------------------------------|-------------------|-----------------------|
| Span about | 15.5m | 50 ft 10 1/4 in |
| Length about | 20.7m | 67 ft 11 in |
| Wing/canard area about | 120m ² | 1,292 ft ² |
| Weights | | |
| Weight empty about | 18 tonnes | 39,683 lb |
| Loaded (normal) | 27 tonnes | 59,500 lb |
| (maximum) | 35 tonnes | 77,160 lb |
| Performance | | |
| Maximum speed (high altitude) | 2,765 km/h | 1,718 mph (Mach 2.6) |
| Maximum cruising speed (dry thrust) | 1,800 km/h | 1,118 mph (Mach 1.69) |
| Range (internal fuel) not less than | 3,000 km | 1,864 miles |



Molniya Buran BTS-002

Purpose: To develop the optimum Buran landing profiles and techniques and train Cosmonauts to fly the Buran spacecraft.

Design Bureau: NPO Molniya, Moscow, General Director Gleb E. Lozino-Lozinskii.

In 1976 the various A I Mikoyan spacecraft - Spiral and Epos, and the 105-11 described previously - were terminated and replaced by the Buran (Snowstorm) programme. This was assigned to NPO Energiya for the rocket launch vehicle, with a total thrust at boost separation of 4,037 tonnes (8,900,000 lb), and NPO Molniya for the reusable winged orbiter. Lozino-Lozinskii, then 67, was transferred from the MiG OKB to head the Molniya team. In 1978 work began on a series of BTS (initials from Russian for Big Transport Ship) projects which eventually totalled eight, BTS-001 through BTS-006 plus BTS-011 and BTS-015. Of these BTS-002 was a complete manned air vehicle to explore the landing profiles and handling, and - together with prolonged training on various other aircraft, notably a Tu-154LL - train the future crews. More than 7,000 atmospheric entries, glides and land-

ings had been simulated mathematically, and in tunnel testing of models, but there was no substitute for actually flying a Buran type vehicle. In summer 1984 BTS-002 was taken by VM-T carrier aircraft to Jubilee airfield near the Cosmodrome at Baikonur. Here it began taxi testing on 29th December 1984.

Almost a year then elapsed before the first flight, on 10th November 1985. This was a single take-off, wide circuit and landing, lasting 12 minutes. The Commander was Igor P Volk and the pilot Rimantas A A Stankys. This crew flew many other missions, together with five other Cosmonauts. An important flight was No 8, on 23rd December 1986, when the Volk/Stankys crew made the first 'hands off automatic approach and landing from a height of 4km.

The last flight of BTS-002 took place on 15th April 1988, just over seven months before the first launch of a Buran in November 1988 made the 'atmospheric analog' redundant. It made a final high-speed taxi test on 20th December 1989 and was then retired, but placed on view to the public at MosAero-92 at Zhukovskii.

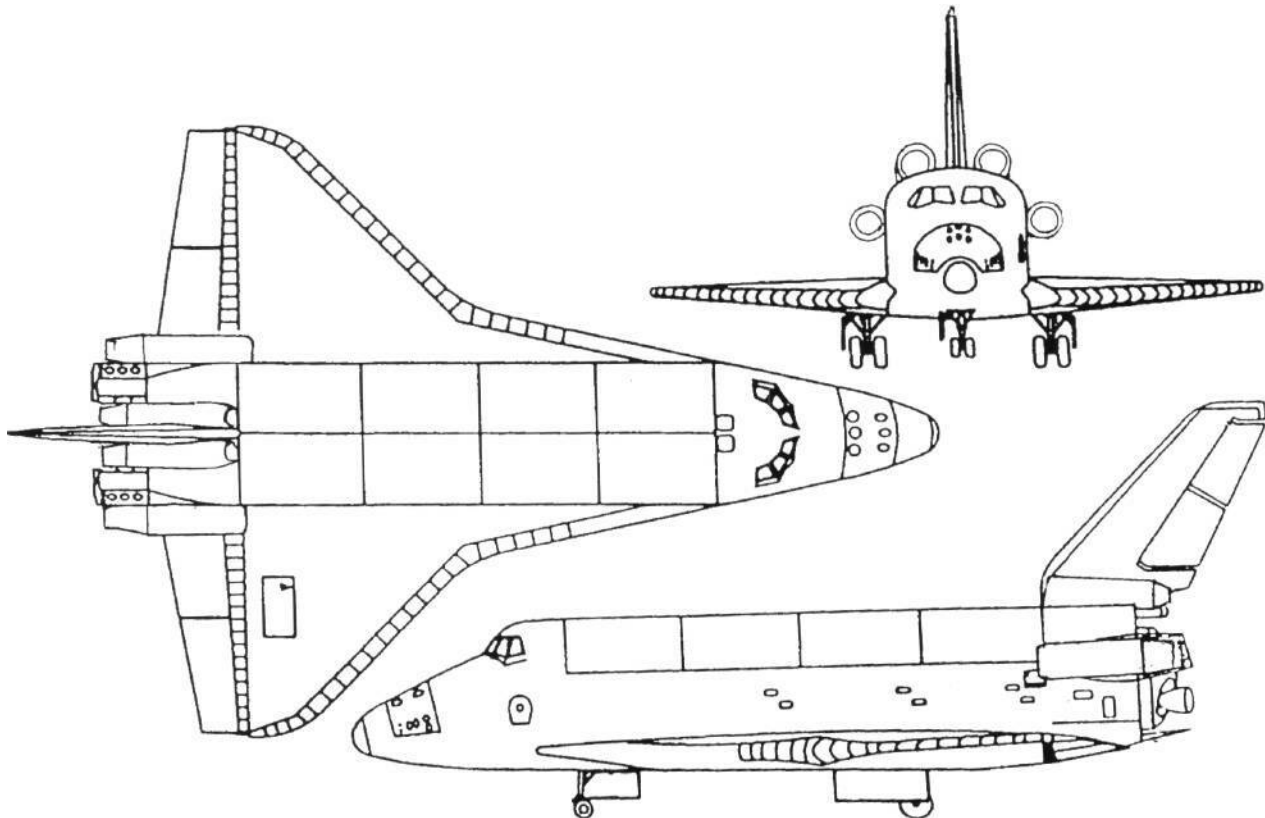
The airframe of BTS-002 was geometrically identical to the Buran, and it had the same flight-control system and software. The four large elevons, four sections of rudder (upper and lower left and upper and lower right, which split apart to act as airbrakes) and door-type ventral airbrake were identical. So were the twin-wheel landing gears, K-36L seats and triple cruciform braking parachutes. On the other hand it was devoid of the 38,000 ceramic tiles and of virtually all the complex on-board systems of the spacecraft.

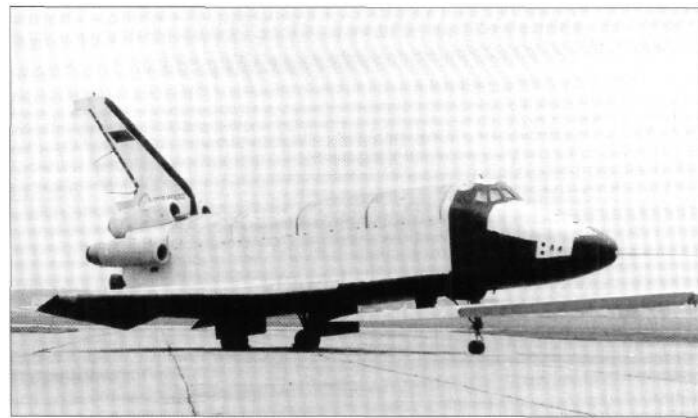
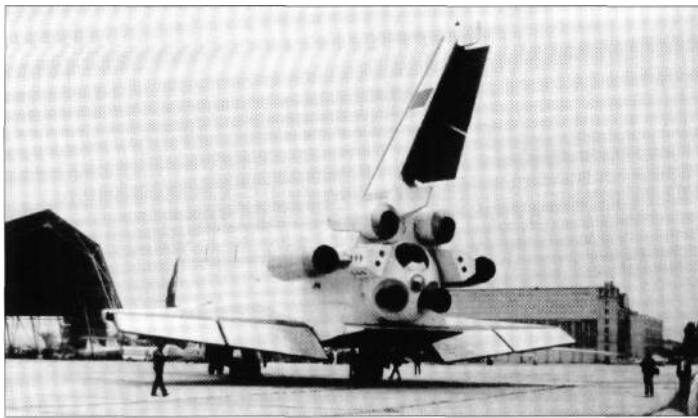
| Dimensions | | |
|------------|--------------------|---|
| Span | 23.92 m | 78 ft 5 ¹ / ₄ in |
| Length | 36.367 m | 119 ft 3 ³ / ₄ in |
| Wing area | 250 m ² | 2,690 ft ² |

| Weights | | |
|-------------------------------|-----------|------------|
| Empty, similar to Buran | 82 tonnes | 180,776 lb |
| Loaded, less than the orbiter | 96 tonnes | 211,640 lb |

| Performance | | |
|-------------------------------------|----------|-----------|
| Normal maximum speed on each flight | 600 km/h | 373 mph |
| Normal peak of trajectory | 4,000 m | 13,123 ft |
| Endurance | 50 min | |

BTS-002





Two views of BTS-002.

In particular, the propulsion systems were totally different. The orbiter had no main engines, relying totally on the mighty launch rocket, but it did have two OMEs (orbital manoeuvring engines) and 42 small thrusters for attitude control in space. The BTS-002 needed none of these, but instead had four Lyul'ka AL-21F-3 afterburning turbojets, each rated at 11,200kg (24,800lb) thrust. These were arranged one on each side of the rear fuselage and one on each side at the base of

the fin. Of course it also needed a conventional kerosene fuel system. The engines were used only for taxiing to the runway and for take-off and landing. The important part of the flight had to be a glide, simulating the orbiter. Presence of the four air-breathing engines was said to have little effect upon the vehicle's flight characteristics.

BTS-002 did everything it was designed to do. Unfortunately, the main Buran programme eventually ran eight years later and

overran its budget severely. Nevertheless, in the opinion of Vyacheslav Filin, Deputy General Constructor at NPO Energiya, 'Had it not been for existence of the Buran system there would have been no Reykjavik meeting where Reagan suggested sharing Star Wars technology and which led to strategic arms reduction'.

Moskalyov SAM-4 Sigma

Purpose: To create a fighter with unprecedented speed.

Design Bureau: Aleksandr Sergeyevich Moskalyov, initially in Leningrad and later at the VGU and Aircraft Factory No 18, Voronezh.

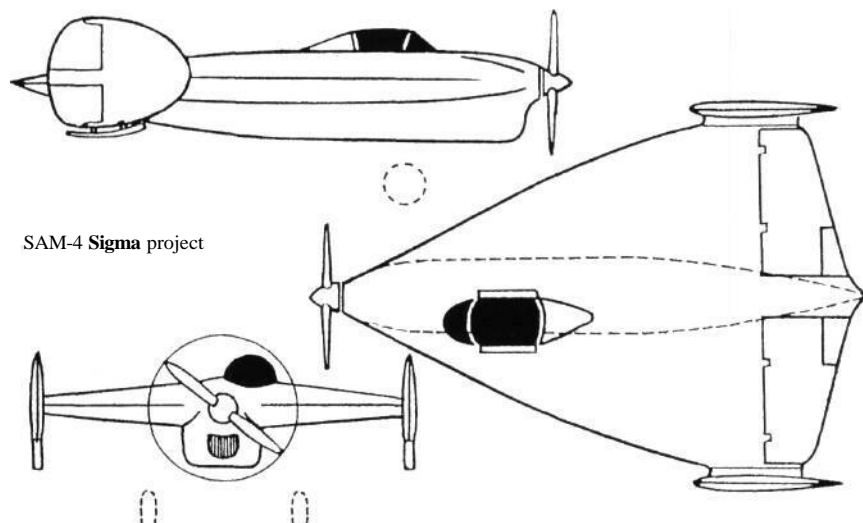
Moskalyov was a talented young designer/pilot who achieved success with conventional aircraft, notably the SAM-5 light transport (SAM stood for Samolyot [aeroplane] Aleksandr Moskalyov). He also persistently strove to create highly unconventional aeroplanes of tailless configurations. The first of the latter series was the Sigma, named for the letter of the Greek alphabet. He sketched this in 1933 whilst working at the Krasnyi Letchik (Red flyer) factory in Leningrad, and worked on rocket propulsion with V P Glushko in a serious endeavour to design an aeroplane to reach 1,000km/h (621 mph), and if possible to exceed Mach 1 (the first project in the world with this objective). When it was clear that a rocket engine with adequate thrust was many years distant, he recast the design with piston engines. He was working on this when he left Leningrad to be a lecturer at the VGU, the State University at Voronezh. Under the guidance of A V Stolyarov he tested models in the VGU's newly built high-speed tunnel. In September 1934 he submitted his preliminary report on SAM-4 to the GlavAviaProm (directorate of aircraft industries), whose Director, 11 Mashkevich, berated Moskalyov for sub-

mitting such 'unimaginable exotics'.

By 1933 Moskalyov had decided a suitable configuration for a fast aircraft was an all-wing layout with a 'Gothic delta' plan shape, with trailing-edge elevons and Scheibe surfaces (fins and rudders on the wingtips). The drawing shows two main wheels in the front view, but this may be an error as Moskalyov favoured a single centreline gear and, as shown, skids on the wingtip fins. The drawing shows a single propeller, but in fact Moskaly-

ov intended to use two Hispano-Suiza 12 Ybrs engines, each of 860hp (these were later made in the USSR under licence as the M-100), driving separate contra-rotating propellers. The stillborn rocket version would have had a prone pilot, but the piston-engined SAM-4 featured a conventional enclosed cockpit; the designer did not explain why this was offset to port.

This proposal was altogether too 'far out' for Mashkevich. No data survives.



SAM-4 Sigma project

Moskalyov SAM-6

Purpose: To test an aeroplane with landing gears on the centreline.

Design Bureau: S A Moskalyov at VGU and GAZNoIS.

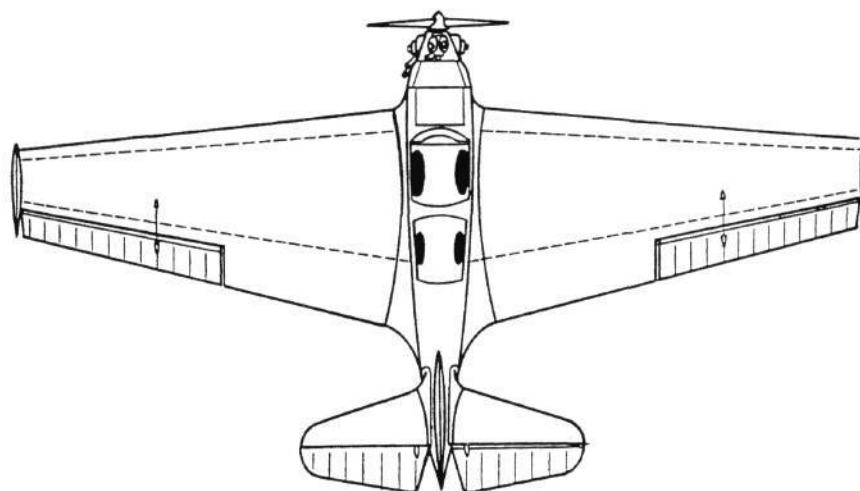
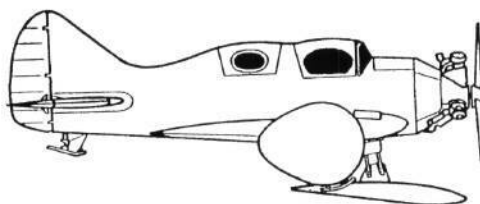
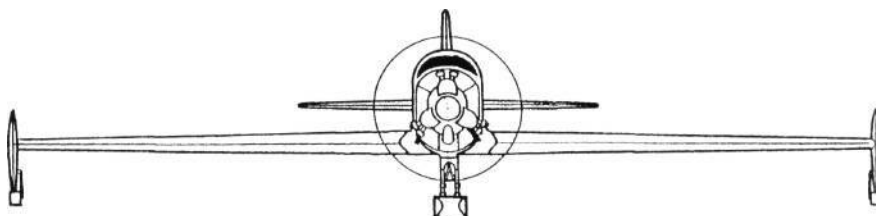
Unaware of the fact that Bartini had already flown the Stal'-6 (see page 16), Moskalyov decided in **1933** that it would be prudent to build a simple low-powered aeroplane to investigate the landing gear he proposed to use for his fighter, with a single mainwheel and skids under the wingtips and tail. It was flown in early 1934, but later in that year it was modified into the SAM-65/s.

The SAM-6 had a conventional tail, though its moment arm was very short and the aircraft was dominated by its relatively huge wing. The structure was wood, with fabric-covered control surfaces. The engine was a three-cylinder M-23 rated at 65hp. Behind the small fuel tank was the open cockpit. The Scheibe fins were not fitted with rudders, and were described by the designer as 'plates'. Initial testing was done in early 1934 on centreline tandem skis. Later the front ski was replaced by a wheel on a sprung leg inside a trouser fairing. After rebuilding as the SAM-66/s testing continued in 1935. This had tandem cockpits with hinged hoods, and in its final form a conventional landing gear was fitted with two trousered mainwheels.

According to Shavrov 'experiments showed that the centreline gear was quite practical'. Moskalyov intended to use such landing gear on the SAM-7, but ultimately decided not to (see original drawing of that aircraft). The following specification refers to the SAM-6b/s.



SAM-66/s



Top right: SAM-6.

Dimensions

| | | |
|-----------|--------------------|--------------------|
| Span | 8.0m | 26 ft 3 in |
| Length | 4.5m | 14 ft 9 in |
| Wing area | 12.0m ² | 129ft ² |

Weights

| | | |
|--------|-------|----------|
| Empty | 380kg | 838 lb |
| Fuel | 50kg | 110 lb |
| Loaded | 500kg | 1,102 lb |

Performance

| | | |
|--------------------|---------|-----------|
| Speed at sea level | 130km/h | 81 mph |
| Service ceiling | 3,000 m | 9,842 ft |
| Range | 200km | 124 miles |
| Landing speed | 55km/h | 34 mph |

Moskalyov SAM-7 Sigma

Purpose: To build a superior two-seat fighter.

Design Bureau: A S Moskalyov, at GAZ No 18, Voronezh.

In 1934 Moskalyov was engaged in engineering later versions of TB-3 heavy bomber for production. This enabled him to use one of this bomber's engines and propellers to power a fighter (though it was hardly ideal for the purpose). Despite the fact that it was far more complex than any of his previous aircraft, and also had advanced all-metal construction, the SAM-7 was completed in October 1935. Pilots considered it potentially dangerous, and factory testing was confined to taxiing at progressively higher speeds, ultimately making short hops in a straight line.

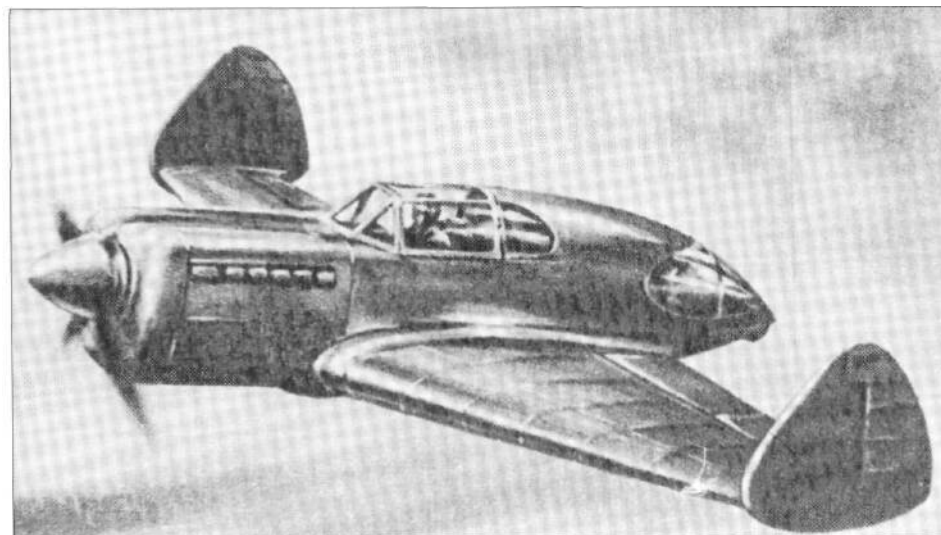
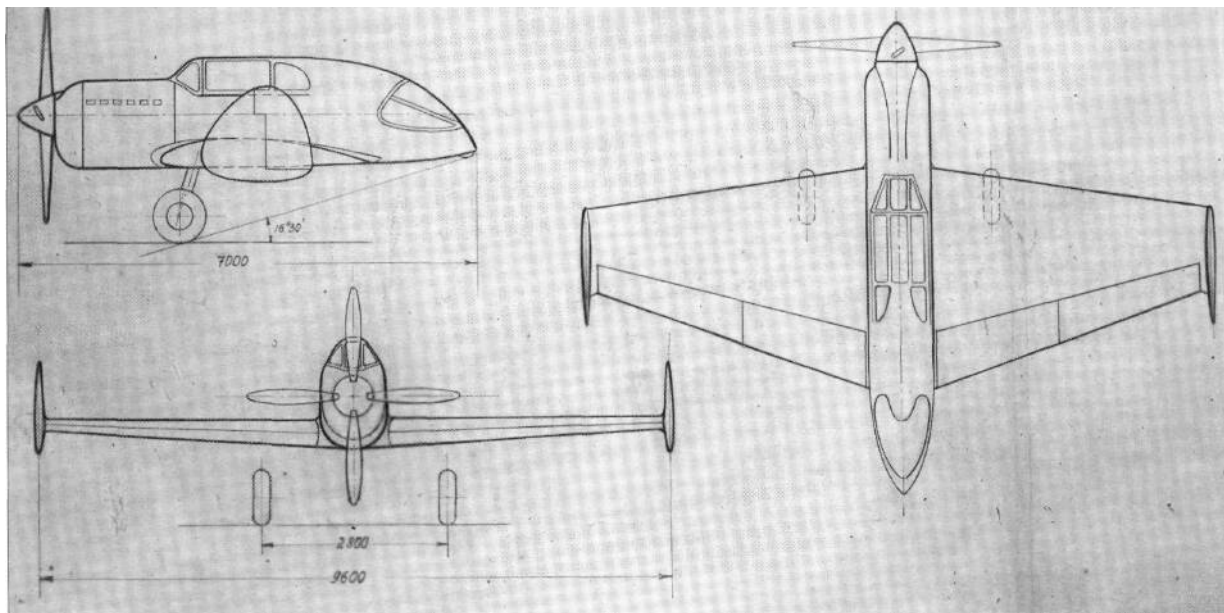
The SAM-7's configuration was described by Shavrov as 'one of the world's most un-

orthodox', but in fact the wing was of fairly normal design, with straight equal taper and an aspect ratio of 4.6. Aerofoil profile was R-II, and the thickness/chord ratio 12 per cent, without twist. Apart from this the Sigma (the designer's second use of this name) was indeed unconventional. There was no tail. On the wingtips were Moskalyov's favoured Scheibe fins, fitted with fabric-covered horn-balanced rudders. On the wing trailing edge were outboard ailerons and inboard elevators which, when depressed to a slight angle, were intended also to serve as slotted flaps (though it is difficult to see how they could do so without putting the aircraft into a dive). The main landing gears had single struts, raked forward, with a track of 2.8m (9ft 2in), and were pivoted to the front spar to retract inwards. The surviving drawing shows a tail-wheel, but Shavrov says there was a non-cas-

toring tailskid. The structure was almost wholly D1 duralumin, the maximum wing skin thickness being 2.5mm. The nose inlet served the carburettors. The 830hp M-34 engine drove a four-blade wooden propeller, and was cooled by a surface evaporative (steam) system similar to that of the Stal'-6. For use at low speeds a normal honeycomb radiator could be cranked down behind the cockpit. The intended armament was two ShKAS fixed above the engine, fired by the pilot, and a second pair mounted on a pivot and aimed by the rear gunner.

One cannot help being astonished that Moskalyov was able to obtain funds to build this aircraft, because there is no mention of any official approval of the design (which would almost certainly have been refused). One feels sympathy with the test pilots, who were probably right to be hesitant.

Original OKB drawing of SAM-7.



Artist's impression of SAM-7.

| | | |
|------------------------------|------------------------------|---------------------|
| Dimensions | | |
| Span (Shavrov) | 9.46 m | 31 ft 14 in |
| (OKB drawing) | 9.6 m to centrelines of fins | |
| Length | 7.0 m | 22 ft 11 1/2 in |
| Wing area | 20.0 m ² | 215 ft ² |
| Weights | | |
| Empty | 940 kg | 2,072 lb |
| Loaded | 1,480 kg | 3,263 lb |
| Performance | | |
| Max speed (estimated) | | |
| at sea level | 435 km/h | 270 mph |
| at altitude | 500 km/h | 311 mph |
| Service ceiling (estimated) | 9,200 m | 30,184 ft |
| Range (estimated) | 800 km | 497 miles |
| The only measured figure was | | |
| the landing speed of | 138 km/h | 86 mph |

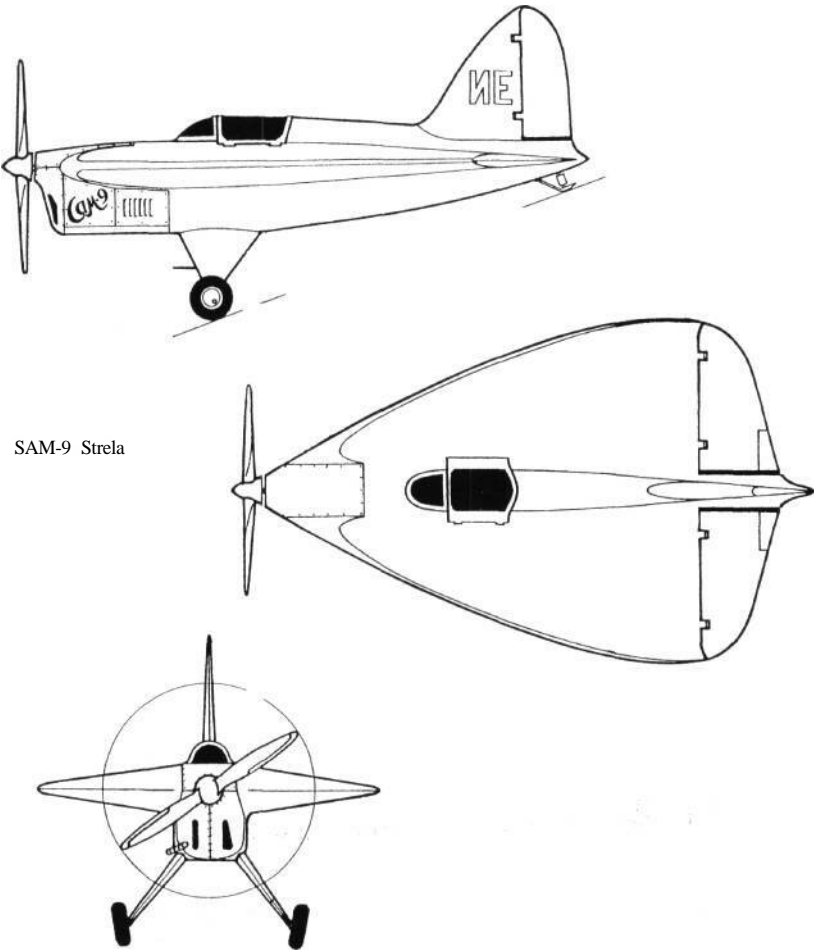
Moskalyov SAM-9 Strela

Purpose: To test at modest speeds an aircraft with a 'Gothic delta' wing of very low aspect ratio.

Design Bureau: A S Moskalyov, from 1936 head of his own OKB-31 at Voronezh.

Always eager to build his incredible SAM-4 dart-like fighter, Moskalyov was rebuffed in these efforts until in 1936 US magazines featured futuristic fighters with low-aspect-ratio wings, shaft drives and prone pilots. This spurred GUAP to invite Moskalyov at least to try out his radical ideas with a simple aircraft with an engine of modest power. Following tunnel tests by V P Gorskiy at CAHI (TsAGI), the SAM-9 was built in 70 days, and flown on skis in early 1937 by N S Rybko at Voronezh. Following six flights by Rybko and A N Gusarov, it was taken to Moscow and tested in short hops by Rybko and A P Chernavskii, finally making eight full flights in the hands of Rybko. The aircraft was tricky, demanding an angle of attack of 22° at take-off and landing, and being unable to climb higher than 1,500m (4,921ft). Despite this the NKAP (state commissariat for aviation industry) suggested that Moskalyov should produce a fighter with a 0.975 aspect ratio wing, and this led to the RM-1.SAM-29.

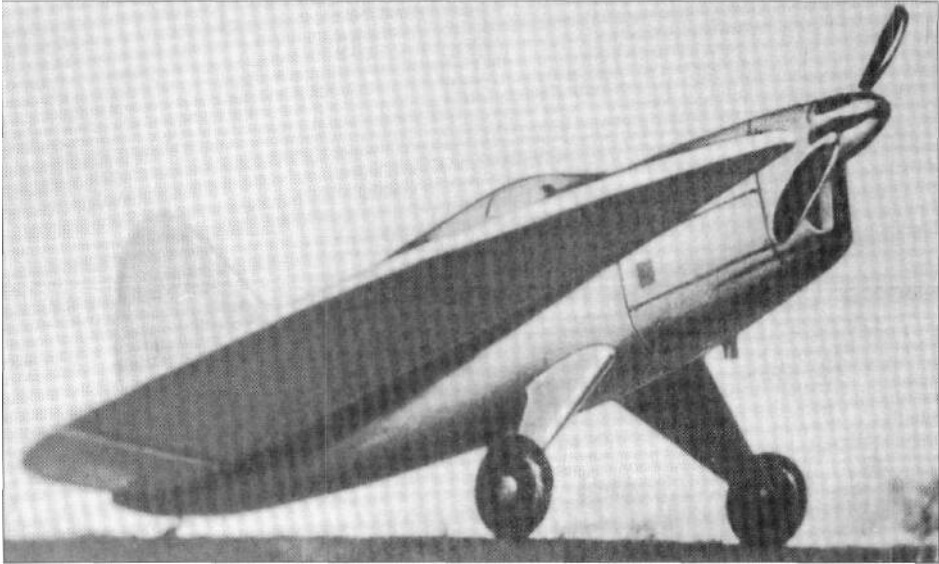
The SAM-9 Strela (Arrow) was made of wood, with a brilliant surface finish, the cable-operated rudder and elevons having fabric covering. The thick aerofoil was of RAF.38 profile, with local modifications. The cockpit was placed between the two main spars, with a hinged canopy. The engine was a Renault MV-4 aircooled inverted 4-cylinder rated at 140hp. The neat main landing gears had pivoted rubber-sprung cantilever legs for skis or wheels, and the tailskid did not castor. The rudder and broad-chord elevons had trim tabs.



Without the support of CAHI (TsAGI) and the (mistaken) belief that such aircraft were planned in the USA, this project would probably have got nowhere. As it was, the SAM-9 merely showed that such aircraft could fly,

but with difficulty. In a recent display of models of Moskalyov aircraft the SAM-9 was depicted entirely doped red except for the propeller blades, and with a placard giving speed and altitude as 340km/h and 3,400m.

| | | |
|--|--------------------|---------------------|
| Dimensions | | |
| Span | 3.55m | 11ft 5 3/4 in |
| Length | 6.15m | 20 ft 2 in |
| Wing area | 13.0m ² | 140 ft ² |
| Weights | | |
| Empty | 470kg | 1,036lb |
| Fuel and oil | 60+10 kg | 132+22 lb |
| Loaded | 630kg | 1,389lb |
| Performance | | |
| Maximum speed actually reached, at sea level | 310km/h | 195 mph |
| Altitude reached | 1,500m | 4,921 ft |
| Take-off run about | 200m | 656ft |
| Landing speed/ run | 102km/h 100m | 63 mph 328ft |



Moskalyov SAM-13

Purpose: To design a small fighter with 'push/pull' propulsion.

Design Bureau: A S Moskalyov, OKB -31 at Voronezh.

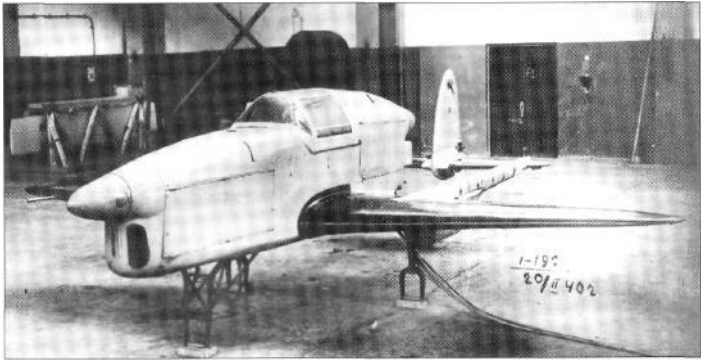
This small fighter was unconventional in layout, but used an ordinary wing, and had nothing to do with the designer's previous fighter concepts. According to Shavrov 'Fokker designed an almost exact copy of the SAM-13, known as the D.23...' In fact it was the other way about, because Moskalyov began this design in 1938, immediately after the D.23 had been exhibited at the Paris Salon. The single prototype was first flown by N D Fikson in late 1940, 18 months after the Dutch fighter, and proved difficult to handle, to need inordinately long runs to take off and land, and to have a sluggish climb and poor ceiling. Its designer worked round the clock to improve it, and by

spring 1941 it was undergoing LII testing in the hands of Mark L Gallai. Apart from the fact the nose gear never did retract fully, it was by this time promising, and it was entered for the summer high-speed race, but the German invasion on 22nd June stopped everything. The No 31 OKB was evacuated, but this aircraft had to be left behind so it was destroyed. The OKB documents have not been found.

The SAM-13 was powered by two 220hp Renault MV-6 inverted six-cylinder aircooled engines driving 2.2m (7ft 2 1/2in) two-blade variable-pitch propellers. Between them was the pilot, and Moskalyov fitted the rear propeller with a rapid-acting brake to make it safer for the pilot to bail out. The small two-spar wing was sharply tapered, and was fitted with split flaps inboard of the booms carrying the single-fin tail. Apart from welded steel-tube engine mounts, the structure was wood-

en, with polished doped ply skin. The main landing gears retracted inwards and the nose unit aft. One drawing shows the nose unit (which had a rubber shimmy damper) to have had a levered-suspension arm for the axle. The intended armament, never fitted, comprised four 7.62mm ShKAS, two above the front engine and two at the extremities of the wing centre section.

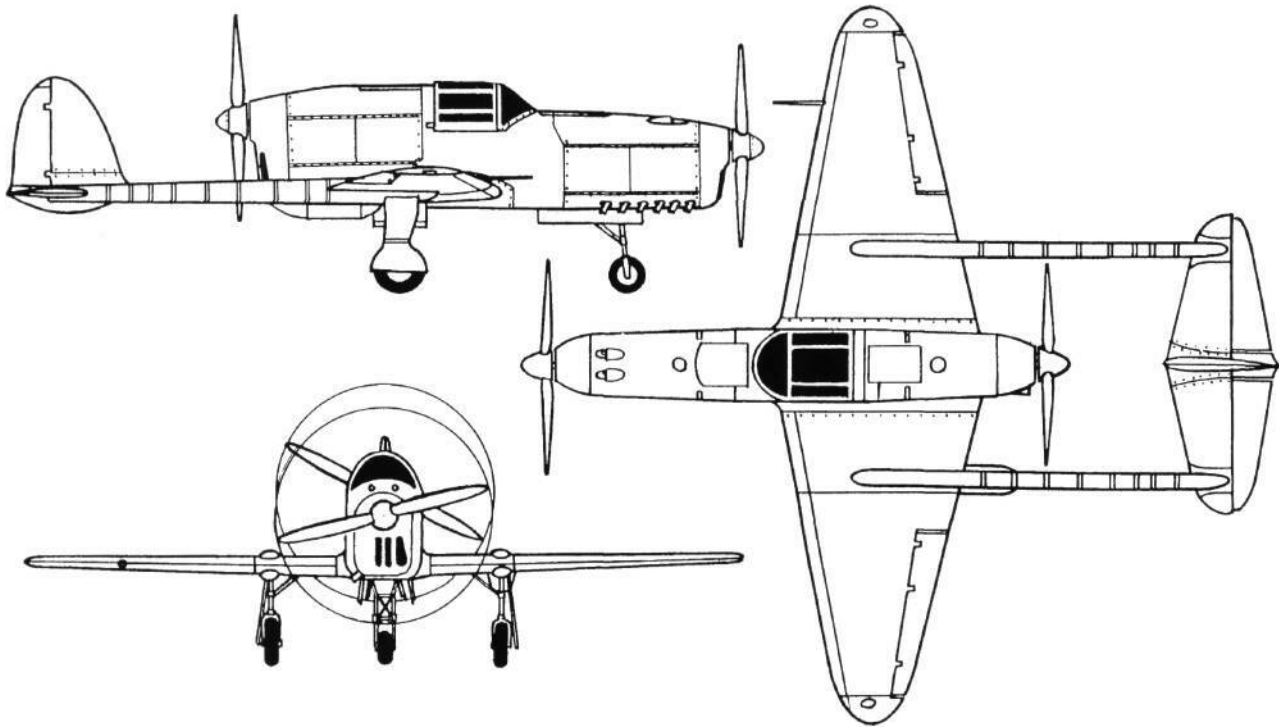
Moskalyov knew that the MV-6 was available for licence-production in the USSR, and thought this aircraft might make good use of some. Even had the programme continued without interruption it is hard to envisage the SAM-13 being adopted by the WS.



SAM-13 in erecting shop, dated 20th February 1940

| | | |
|---|-------------------|---------------------|
| Dimensions (note: Shavrov's dimensions are incorrect) | | |
| Span | 7.3m | 23ft 11 1/2 in |
| Length | 7.85m | 25 ft 9 in |
| Wing area | 9.0m ² | 96.9ft ² |
| Weights | | |
| Empty | 754kg | 1,662lb |
| Loaded | 1,183kg | 2,608 lb |
| Performance | | |
| Max speed (design figures) | | |
| at sea level | 463km/h | 288 mph |
| at 4,000m (13,123 ft) | 680km/h | 423 mph |
| Service ceiling (estimate) | 10,000m | 32,808 ft |
| Range (estimate) | 850 miles | 528 miles |
| Landing speed | 125km/h | 78 mph |

SAM-13



Moskalyov SAM-29, RM-1

Purpose: To renew attempt to build a rocket-engined interceptor.

Design bureau: A S Moskalyov, No 31.

During the Great Patriotic War practical rocket engines for manned aircraft became available. Moskalyov never forgot that he had been invited by the NKAP to build a fighter with the so-called Gothic delta wing of 0.95 aspect ratio. In 1944, despite much other work, he collaborated with L S Dushkin in planning what was to be the ultimate Strela

fighter. This time most of the technology existed, and S P Korolyov lent his support, but once the War was over such a project was judged to be futuristic and unnecessary. Moskalyov's OKB was closed in January 1946, and he returned to lecturing, but he continued to study this project for two further years.

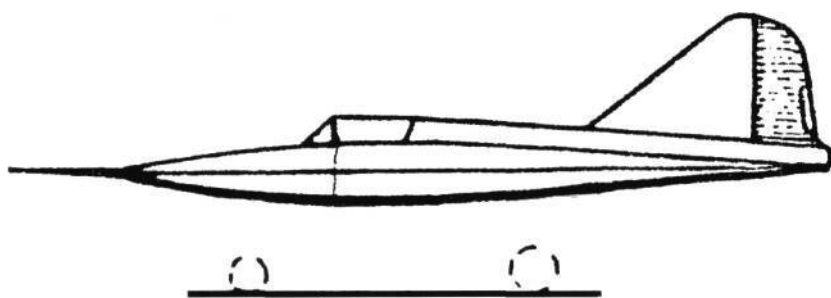
The final SAM, also called Raketnyi Moskalyov, would have followed the usual Strela form in having a Gothic delta wing and no horizontal tail. The wing was fitted with elevons and blended into a needle-nosed

fuselage carrying a large fin and rudder. The Dushkin RD-2M-3V engine, rated at 2,000kg (4,409 lb) thrust at sea level and much more at high altitude, was installed at the rear and fed with propellants from tanks filling most of the airframe. Two cannon would have been installed beside the retracted nose landing gear.

This was yet another of this designer's near misses, all of which stemmed from his abundance of enthusiasm.

No data survives.

Two sketches, one called SAM-29, the other RM-1.



Myasishchev M-50 and M-52

Purpose: To design a long-range supersonic bomber.

Design Bureau: OKB-23 of Vladimir Mikhailovich Myasishchev, Moscow.

In 1955, when the Myasishchev OKB was still striving to develop the huge 3M subsonic bomber, this design bureau was assigned the additional and much more difficult task of creating a strategic bomber able to make dash attacks at supersonic speed. The need for this had been spurred by the threat of the USAF Weapon System 110, which materialised as the XB-70. The US bomber was designed for Mach 3, but in 1955 this was considered an impossible objective for the Soviet Union. From the outset it was recognized that there could be no question of competing prototypes from different design teams. Even though the Myasishchev OKB was already heavily loaded with completing development of the huge M-4 strategic bomber and redesigning this into the 3M production version, this was the chosen design bureau. In partnership with CAHI (TsAGI), wind tunnels were built for Mach 0.93, 3.0 and 6.0. The two partners analysed more than 30

possible configurations, initially in the Izdeliye (product) '30' family (VM-32, tailless VM-33 and VM-34). The basic requirement was finally agreed to specify a combat radius not less than 3,000km (1,864 miles) and if possible much more, combined with a dash speed (with engine afterburners in use) of Mach 2. This demanded an upgraded aircraft, and the result was the '50' series, starting with the M-50. Under chief designer Georgi Nazarov this was quickly accepted, and the initial programme comprised a static-test specimen and two flight articles, comprising one M-50 followed by an M-52. OKB pilots N I Goryainov and A S Lipko flew the M-50 on 27th October 1959. Modified with afterburning inboard engines, it continued testing in late 1960, but was by this time judged to be of limited value, and to be consuming funds needed for ICBMs (intercontinental ballistic missiles) and space projects. The OKB-23 was closed, and its personnel were transferred to V N Chelomey to work on ICBMs and spacecraft. Myasishchev was appointed Director of CAHI. To the protestations of some, the virtually complete M-52 was scrapped, and six later 50-series projects re-

mained on the drawing board. However, for propaganda purposes the M-50 was kept air-worthy and made an impressive but rather smoky flypast at the Aviation Day parade at Moscow Tushino on 9th July 1961, naturally causing intense interest in the West. After being photographed with different paint schemes, and the successive radio callsigns 022, 023, 12 and 05, it was parked in the nose-high take-off attitude at Monino.

Apart from the totally different wing, in overall configuration, size and weight the M-50 exactly followed the M-4 and 3M family. Despite this every part was totally new, to the last tyre and hydraulic pump. The wing was of pure delta shape, with CAHI R-II profile of only 3.5 to 3.7 per cent thickness, and with a leading-edge angle of 50° from the root to the inboard engines at 55 per cent semi-span, and 41° 30' from there to the tip. The tip was cropped to provide mountings for the outboard engines. The leading edge was cambered but fixed, while the trailing edge carried rectangular double-slotted flaps and tapered outboard flaperons. At the time this was by far the largest supersonic wing ever flown. Structurally it was based on a

rectangular grid with four transverse spars and seven forged ribs on each side, the skin being formed by forged and machined panels. The enormous fuselage was of almost perfect streamline form, which like the wing was skinned with forged and machined panels. Only a small two-bay section in the nose formed the pressure cabin for the pilot and navigator seated in tandem downward-ejecting seats. These were lowered on cables for the crew to be strapped in at ground level, then winching themselves into place. There was neither a fin nor fixed tailplanes. Instead the tail comprised three surfaces, each with a forward-projecting anti-flutter weight and driven by a quadruple power unit in the twin duplex hydraulic systems. A back-up mechanical control was provided, with rods and levers, but it was expected that this would later be removed. Several possible engines were studied, the finalists being VADobrynin's VD-10 and PF Zubts' 16-17, which was replaced by the 17-18. Construction of the aircraft outpaced both, and in the end the M-50 had to be powered by two Dobrynin VD-7 turbojets on the underwing pylons and two more on the wingtips. As these were temporary they were installed in simple nacelles with plain fixed-geometry inlets. Rated at 9,750kg (21,495lb), these were basically the same engines as those of the 3M. Likewise the main landing gears appeared to be similar to those of the previous bomber, but in fact they were totally new. One of the basic design problems was that the weapons bay had to be long enough to carry the 11m (36ft) M-61 cruise missile internally. This forced the rear truck, bearing 63 per cent of the weight, to be quite near the tail, reducing the effective mo-

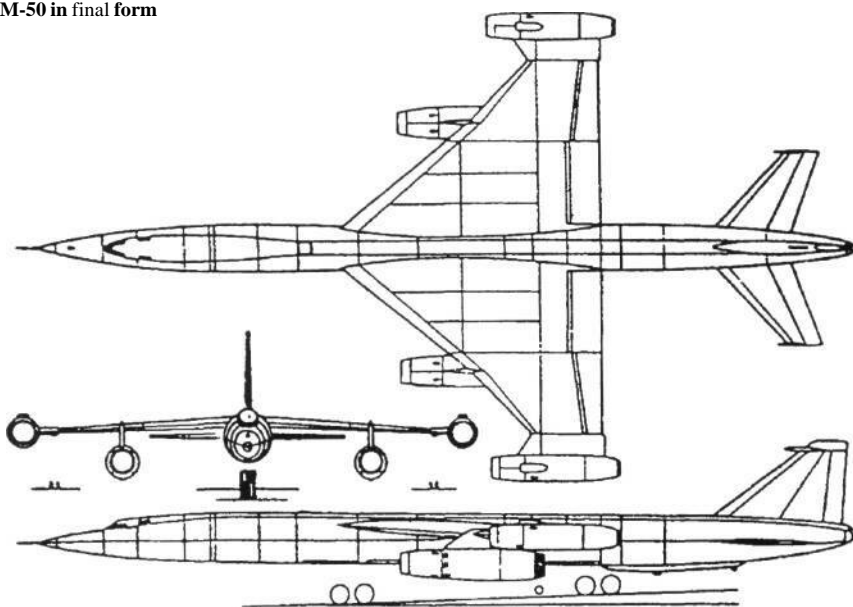
ment arm of the tailplanes and threatening to make it impossible for the pilot to rotate the aircraft on take-off. One answer would have been to use enormous tailplanes, greatly increasing drag, but a better solution was to do what the OKB had pioneered with the M-4 and 3M and equip the steerable front four-wheel landing gear with a double-extension hydraulic strut. Triggered by the airspeed reaching 300km/h (186mph), this forcibly rotated the aircraft 10° nose-up. Another unique feature was that each main gear incorporated a unique steel-shod shoe which, after landing, was hydraulically forced down on to the runway, creating a shower of sparks but producing powerful deceleration, even on snow. For stability on the ground twin-wheel tip protection gears were fitted, retracting forwards immediately inboard of the wingtip engines. All fuel was housed in the fuselage, and yet another unique feature was that to cancel out the powerful change in longitudinal trim caused by the transonic acceleration to supersonic flight fuel was rapidly pumped from No1 tank behind the pressure cabin to No 8 tank in the extreme tail (and pumped back on deceleration to subsonic flight). Over 10 years later the same idea, credited by Myasishchev to L Minkin, was used on Concorde. Flight testing of the M-50 at Zhukovskii was remarkably rapid, though the aircraft proved stubbornly subsonic, stopping at Mach 0.99 even in a shallow dive at full power. In early 1960 the M-50 was modified with afterburning VD-7M engines with a maximum rating of 16,000kg (35,275 lb) on the inboard pylons and derated VD-7B engines rated at 9,500kg (20,944 lb) on the wingtips. This was considered to offer the best compromise between

available thrust, mission radius and propulsion reliability. The engine installations were redesigned, all four having large secondary cooling airflows served by projecting ram inlets above the nacelle. The outer engines were mounted on extensions to the wing housing new wingtip landing gears which retracted backwards.

The M-52 was under construction from November 1958 and differed in many respects. It was to be powered by four Zubts 17-18 bypass engines each rated at 17,700kg (39,021 lb). All four were served by efficient variable multi-shock inlets. The inner engines were 'set at an angle in relation to the chord line' and the outers were attached to larger pylons with forward sweep. The nose was redesigned and housed navigation/bombing radar, the crew sat side-by-side, a small horizontal surface was added on top of the rudder, a retractable flight-refuelling probe was added, the interior was rearranged, a remotely controlled barbette was fitted in the tail with twin GSh-23 guns, and provision was made to carry one M-61 internally or four Kh-22 cruise missiles scabbled on semi-externally in pairs conforming to the Area Rule. This aircraft was structurally complete in 1960 but when OKB-23 was closed it was scrapped.

The M-50 was an extraordinary example of an aircraft which physically and financially was on a huge scale yet which had very limited military value. Not least of the remarkable features of this programme was its relative freedom from technical troubles, even though virtually every part was totally new.

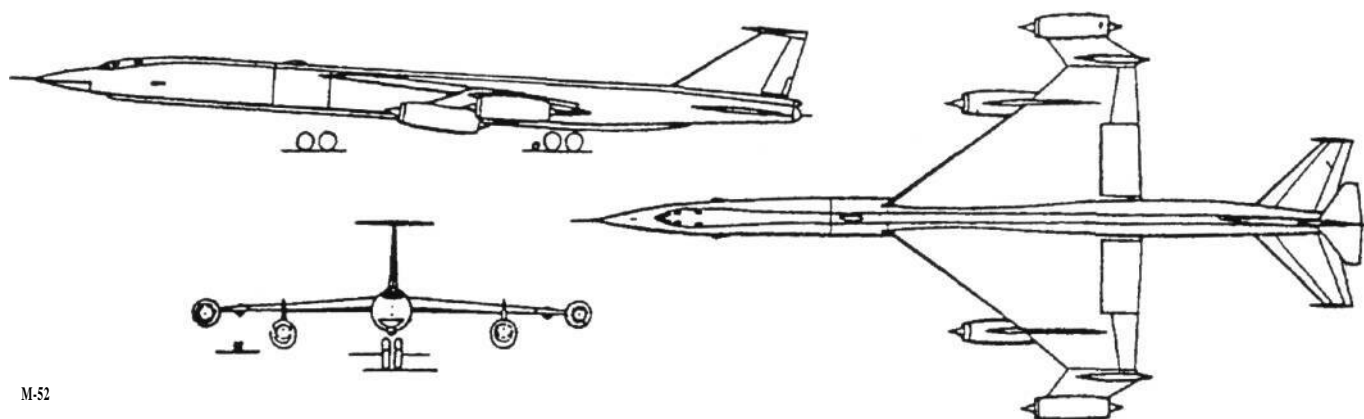
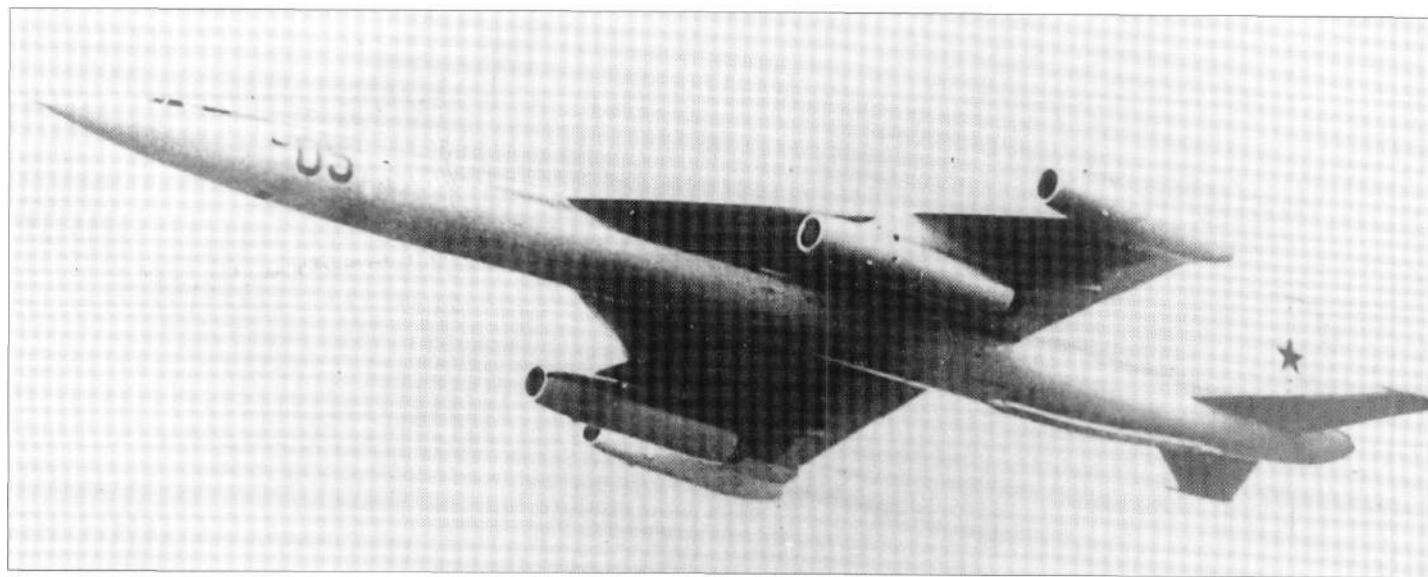
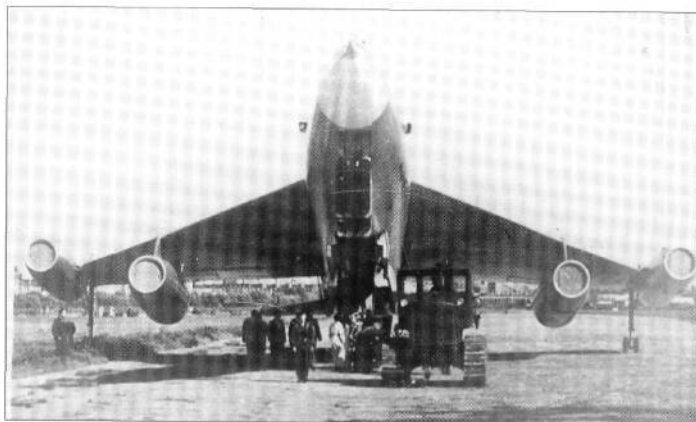
M-50 in final form



| Dimensions (M-50 in 1960) | | |
|-----------------------------|----------------------|-----------------------|
| Span (over outer engines) | 35.1 m | 115ft 2in |
| Length | 57.48 m | 188 ft 7 in |
| Wing area | 290.6 m ² | 3,128ft ² |
| Weights | | |
| Empty | 76,790 kg | 169,290 lb |
| Normal loaded | 203,000kg | 447,531 lb |
| Performance | | |
| Max speed (estimated) | 1,950 km/h | 1,212 mph (Mach 1.84) |
| Cruising speed | 800 km/h | 497 mph |
| Service ceiling | 16,500m | 54,134ft |
| Practical range (estimated) | 7,400 km | 4,598 miles |
| Landing speed (lightweight) | 215 km/h | 133.6 mph |



Four views of M-50 prototype at different periods.



M-52

Myasishchev 3M-T and VM-T Atlant

Purpose: To transport outsize cargoes.

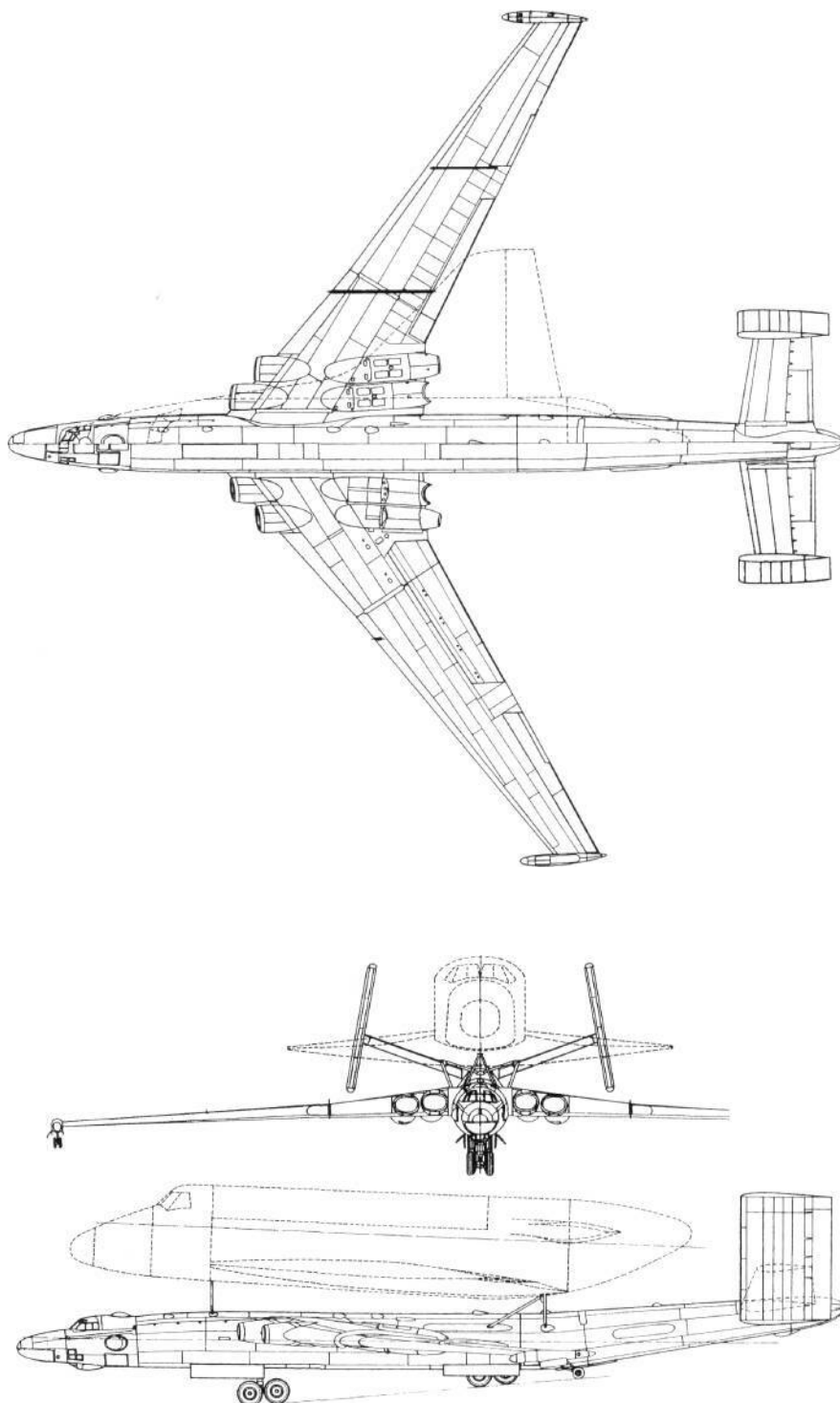
Design Bureau: EMZ (Eksperimental'nyi Mashinostroitel'nyi Zavod, experimental engineering works) named for VMMyasishchev.

After directing CAHI (TsAGI) from 1960, Myasishchev returned to OKB No 23 in early 1978 in order to study how a 3M strategic bomber might be modified to convey large space launchers and similar payloads. In particular

an aircraft was needed to transport to the Baikonur launch site four kinds of load: the nose of the Energiya launcher; the second portion of Energiya; the Energiya tank; and the Buran spacecraft, with vertical tail and engines removed. These loads typically weighed 40 tonnes (88,183 lb) and had a diameter of 8m (26ft). Myasishchev had previously calculated that such loads could be flown mounted above a modified 3M bomber. He died on 14th October 1978, the programme being continued by V Fedotov. While design went ahead, three 3MN-II tanker aircraft were taken to SibNIA (the Siberian State Research Institute named for SACHaplygin) and put through a detailed structural audit preparatory to grafting on a new rear fuselage and tail, and mountings for the external payload. The modified aircraft were designated 3M-T. All were rebuilt with zero-life airframes and new engines, but initially without payload attachments. One was static-tested at CAHI while the other two were completed and flown, the first on 29th April 1981. After a brief flight-test programme they were equipped to carry pick-a-back payloads, and in Myasishchev's honour redesignated VM-T Atlant. The first flight with a payload was made by AKucherenko and crew on 6th January 1982. Subsequently the two Atlant aircraft carried more than 150 payloads to Baikonur.

The most obvious modification of these aircraft was that the rear fuselage was replaced by a new structure 7m (23ft) longer and with an upward tilt, carrying a completely new tail. This comprised modified tailplanes and elevators with pronounced dihedral carrying inward-sloping fins and rudders of almost perfectly rectangular shape, with increased total area and outside the turbulent wake from any of the envisaged payloads. Less obvious was the fact that, even though the maximum take-off weight was less than that for the bomber versions, the airframe was strengthened throughout. As time between overhauls was not of great importance the original four VD-7B engines were replaced by the VD-7M. These were RD-7M-2 engines, originally built for the Tu-22 supersonic bomber with afterburners and variable nozzles, which had had the afterburner replaced by a plain jetpipe and fixed-area nozzle. Thrust was 11,000kg (24,250 lb). These were in turn replaced by the VD-7D, rated at 10,750kg (23,700 lb). Each aircraft was fitted with 14 attachment points above the fuselage and on lateral rear-fuselage blisters for the four different kinds of supporting structure, each being specially tailored to its payload. They were also equipped with a modified

VM-T No 2 (01502) with Buran

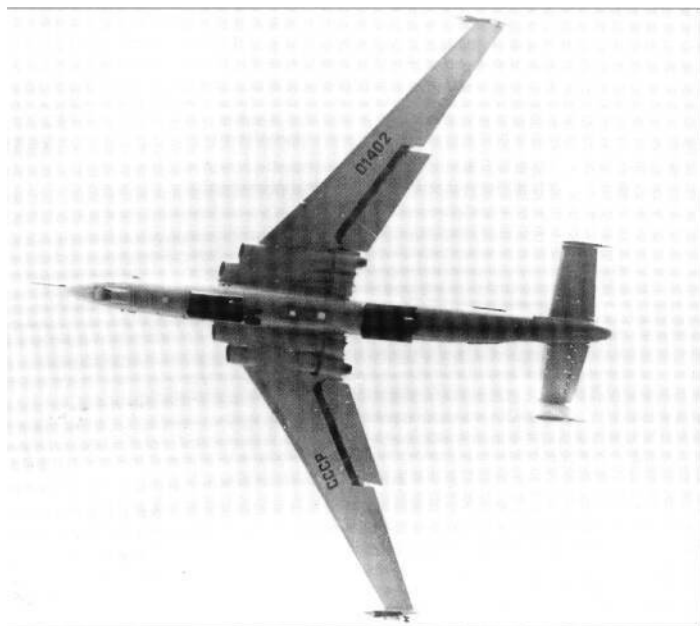


flight-control and autopilot system. The forward fuselage was furnished with work stations for a crew of six. The aircraft were given civilian paint schemes, one being registered RF-01502 and the other being RF-01402 and fitted with a flight-refuelling probe. To support their missions the PKU-50 loading and un-

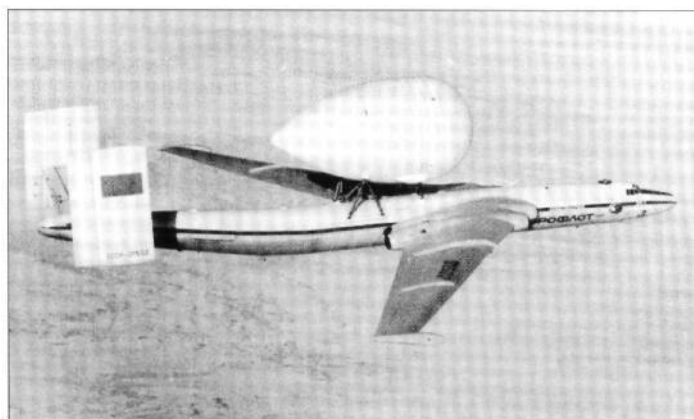
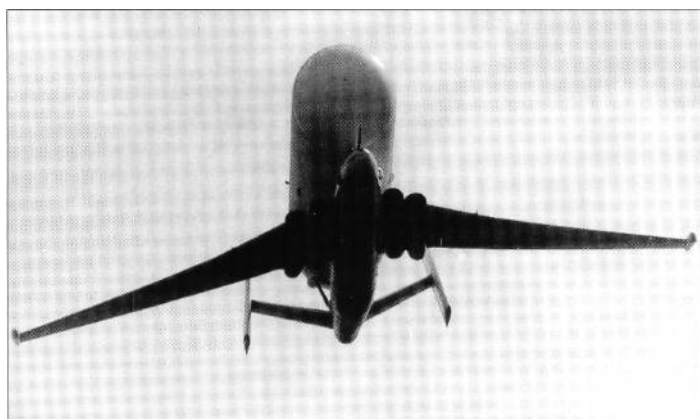
loading facility was constructed at spacecraft factories, including NPO Energiya at Moscow Khimki, and at the Baikonur Cosmodrome. These incorporated a giant gantry for carefully placing the payloads on the carrier aircraft.

Despite the turbulent aerodynamics downstream of the external payloads, this dramat-

ic reconstruction proved completely successful. In the USA a 747 was used to airlift Shuttle Orbiters, but no other aircraft could have carried the sections of Energiya.

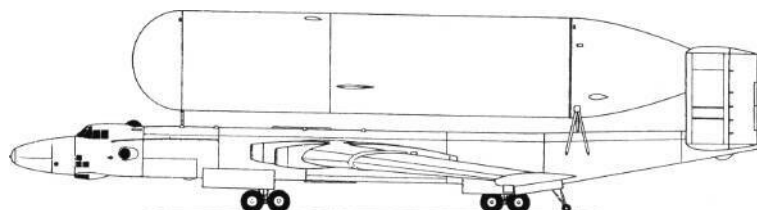


Three views of VM-T No 1 (01402), two showing Energiya main tanks.

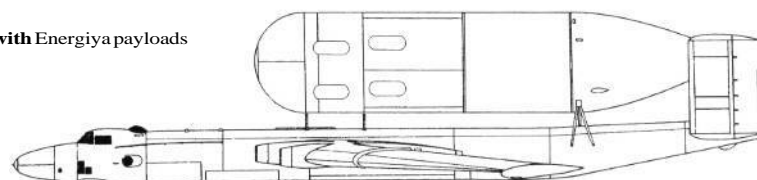


Below: VM-T No 2 with Energiya second-stage tank.

| Dimensions | | |
|--------------------------------------|----------------------|-----------------------|
| Span | 53.16m | 174 ft 5 in |
| Length (no probe) | 58.7m | 192 ft 7 in |
| Wing area | 351.78m ² | 3,787 ft ² |
| Weights | | |
| Empty | 81,200kg | 179,012 lb |
| Maximum payload | 50 tonnes | 110,229 lb |
| Maximum take-off | 192,000kg | 423,280 lb |
| Performance | | |
| Cruising speed | 540 km/h | 290 knots, 335.5 mph |
| Cruise altitude typically | 8,500m | 27,887 ft |
| Range (maximum fuel) | 3,000 km | 1,864 miles |
| compared with 10,950 km for the 3MN. | | |



VM-T with Energiya payloads



Myasishchev M-17 Stratosfera

Purpose: To fly reconnaissance missions at very high altitude.

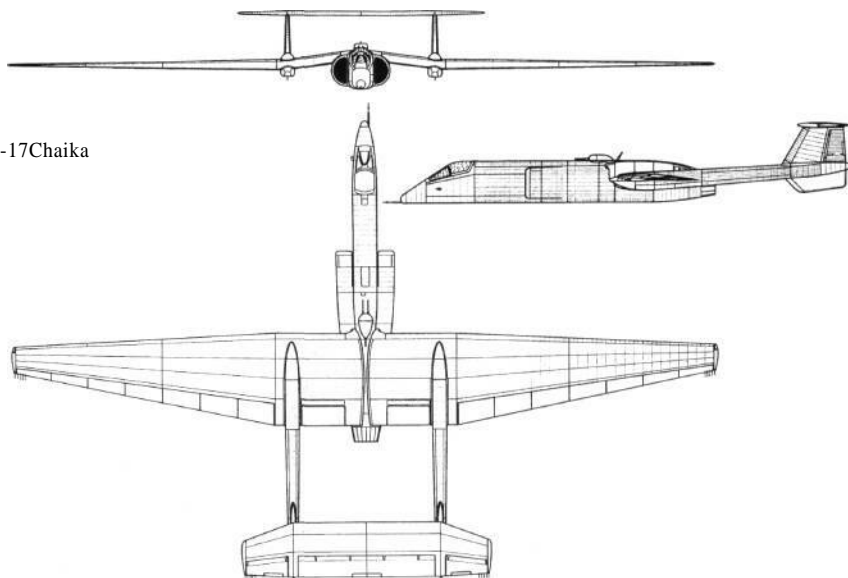
Design Bureau: EMZ named for VM Myasishchev.

Though not an experimental aircraft, the M-17 qualifies for this book because of its nature, its ancestry, and the fact that it was the basis for the M-55 research aircraft. The concept of manned reconnaissance aircraft penetrating hostile airspace at extreme altitude was com-

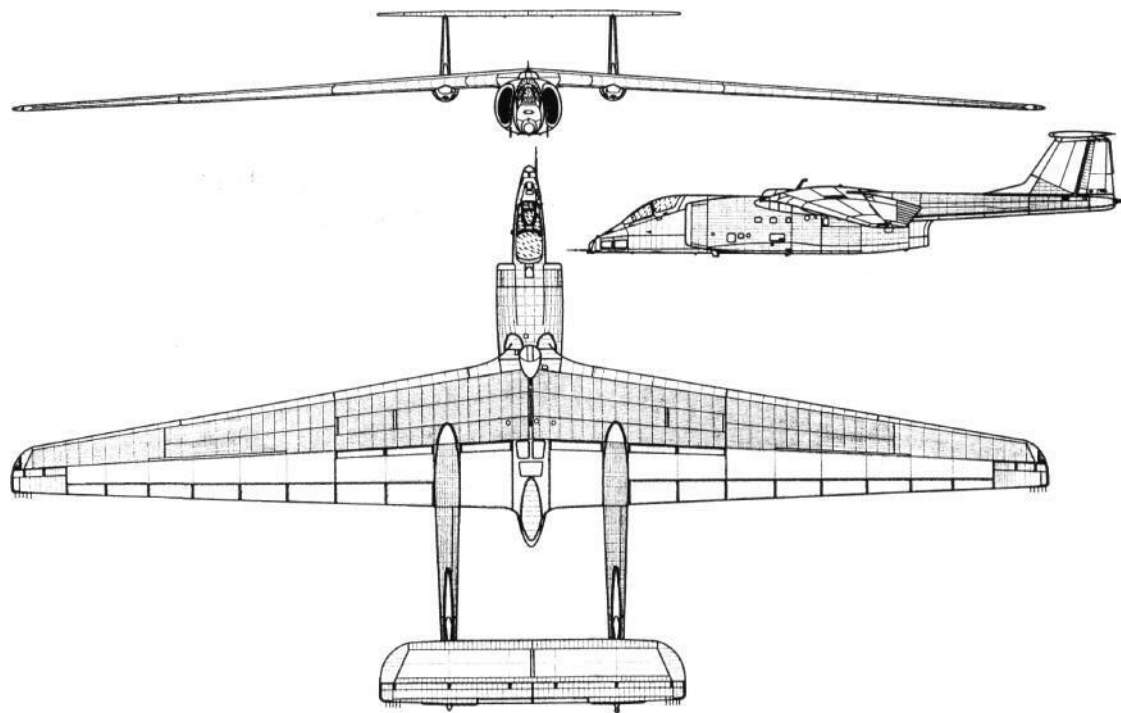
mon in the Second World War, and in the Cold War reached a flash point on 1st May 1960 when the U-2 of F G Powers, a CIA pilot, was shot down over Sverdlovsk. One of the American alternatives studied and then actually used was unmanned balloons launched in such a way that prevailing winds would carry them across Soviet territory. They could change altitude, and could carry not only reconnaissance systems but also explosive charges. This threat could have been serious,

and the PVO (air defence forces) found it difficult to counter. Though still at CAHI, Myasishchev was made head of a secret EMZ tasked with Subject 34, a high-altitude balloon destroyer. Called Chaika (Gull) from its inverted-gull wing, it was to be powered by a single Kolesov RD-36-52 turbojet of 12,000kg (26,455lb) thrust. To reduce jetpipe length the tail was carried on twin booms. In the nose was to be radar and the highly pressurized cockpit, while between the engine inlet ducts was a remotely controlled turret housing a twin-barrel GSh-23 gun. Secretly built at Kumertau helicopter plant in Bashkirya, the Chaika was first flown in December 1978 by K V Chernobrovkin. He had been engaged in taxi tests, and had not meant to take off but in a snowstorm became airborne to avoid hitting the wall of snow on the right side of the runway. In zero visibility he hit a hillside. The programme was relocated at Smolensk, where the second aircraft was constructed to a modified design, designated M-17. The first, No 17401, was first flown by E V ChePtsov at Zhukovskii on 26th May 1982. It achieved a lift/drag ratio of 30, and between March and May 1990 set 25 international speed/climb/height records. In 1992 it investigated the 'hole' in the ozone layer over the Antarctic. The second M-17, No 17103, was equipped with a different suite of sensors. From the M-17 was derived the M-55 Geofizika described next.

M-17Chaika

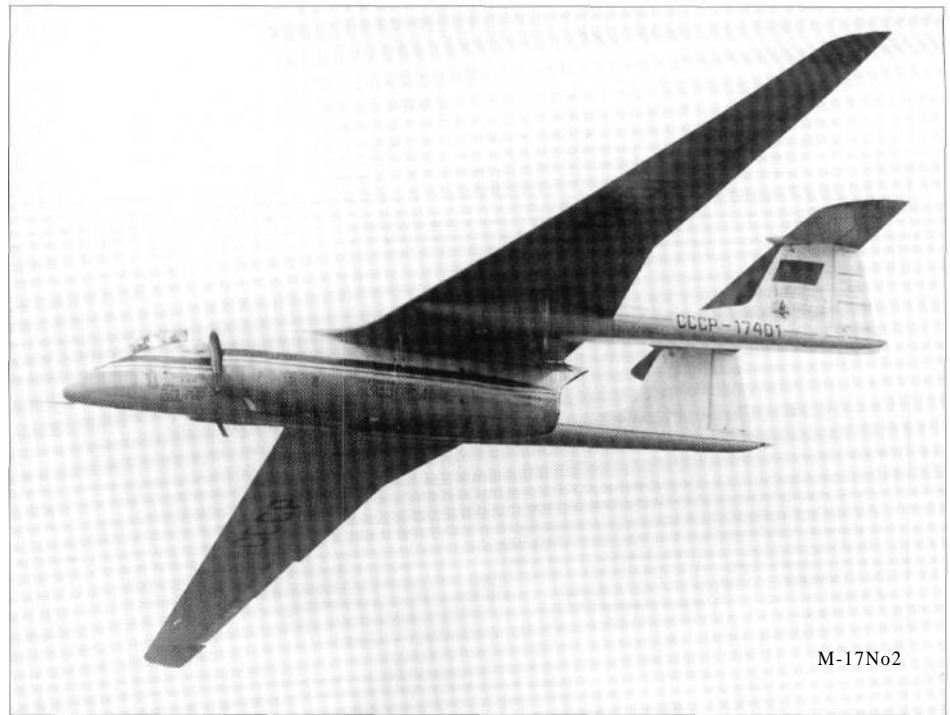


M-17 prototype



| | | |
|---|---------------------|----------------------|
| Dimensions | | |
| Span | 40.32 m | 132ft3Kin |
| Length | 22.27 m | 73 ft Kin |
| Wing area | 137.7m ² | 1,482ft ² |
| Weights | | |
| Empty | 11,995kg | 26,444 lb |
| Loaded | 18,400kg | 40,564 lb |
| Maximum take-off | 19,950 kg | 43,981 lb |
| Performance | | |
| Maximum speed | | |
| at 5 km (16,404 ft) | 332km/h | 206 mph |
| at 20 km (65,617 ft) rising to 743 km/h | | 462 mph |
| Service ceiling from max take-off weight, reached in 35 min | | |
| 21,550 m | | 70,700ft |
| Range at 20 km at Mach 0.7 with 5 % reserve | | |
| 1,315km | | 817miles |
| Take-off run | | |
| at 18,400 kg (40,564lb) | 340m | 1,115ft |
| Landing speed/run | | |
| at 16,300 kg (35,935 lb) | 950m | 3,117ft |

The M-17 had an all-metal stressed-skin structure designed to the low factor of 2. The remarkable wing had an aerofoil of P-173-9 profile and aspect ratio of 11.9, and on the ground it sagged to an anhedral of $2^{\circ} 30'$. The original wing had 16 sections of Fowler flap and short ailerons at the tips, but it was re-designed to have a kinked trailing edge with simplified flaps and longer-span two-part ailerons. Large areas of wing and tail were skinned with honeycomb panels. Flight controls were manually operated, in conjunction with a PK-17 autopilot. The tricycle landing gears retracted hydraulically, the 210kg/cm² (3,000 lb/in²) system also operating other ser-



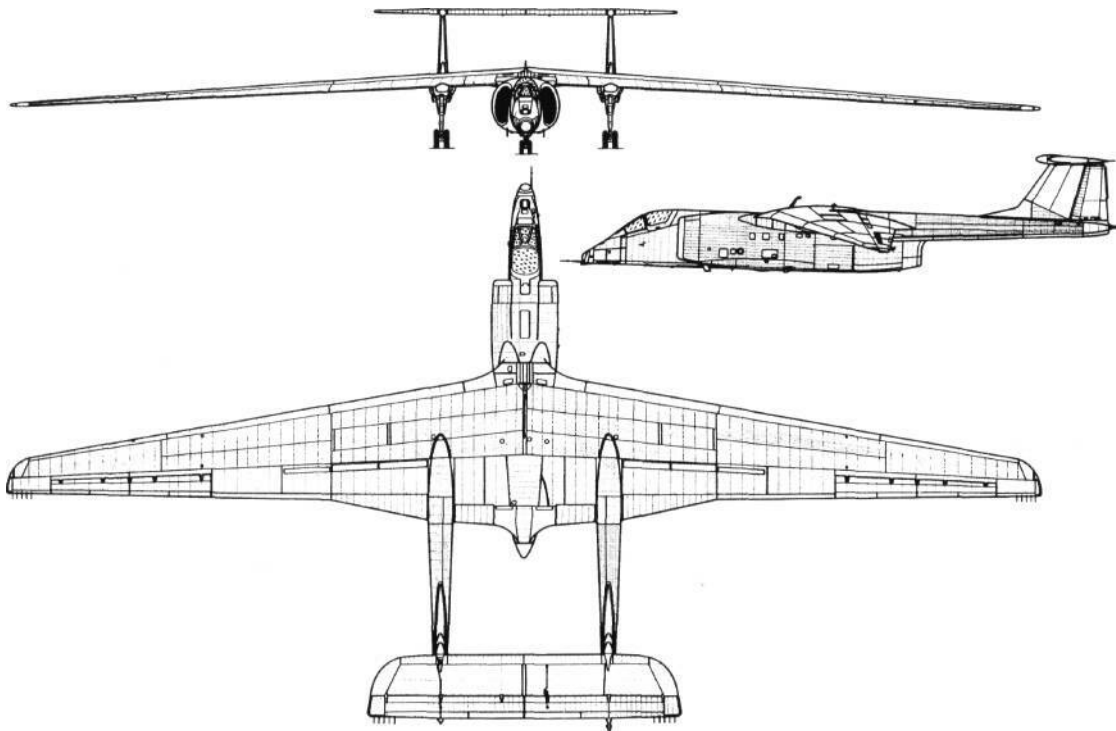
M-17No2

vices including three airbrakes above each wing. The engine was an RD-36-51V, with a take-off rating of 12,000kg (26,455 lb) and nominal thrust of half this value. Cruise thrust at 21,000m (68,898ft) was 600kg (1,323lb). T-8V kerosene was housed in two 2,650 litre main tanks, two 1,550 litre reserve tanks and a 1,600 litre collector tank, a total of 10,000 litres (2,200 Imperial gallons). The pressurized and air-conditioned cockpit housed a

very fully equipped K-36L seat, and among other equipment the pilot wore a VKK-6D suit and VK-3M ventilated suit, and a ZSh-3M protective helmet and KM-32 mask overlain by a GSh-6A pressurized helmet. Avionics were extremely comprehensive.

The M-17 fulfilled all its design objectives. The successive changes in both mission and aircraft design were caused solely by political factors.

M-17 production



Myasishchev M-55 Geofizka



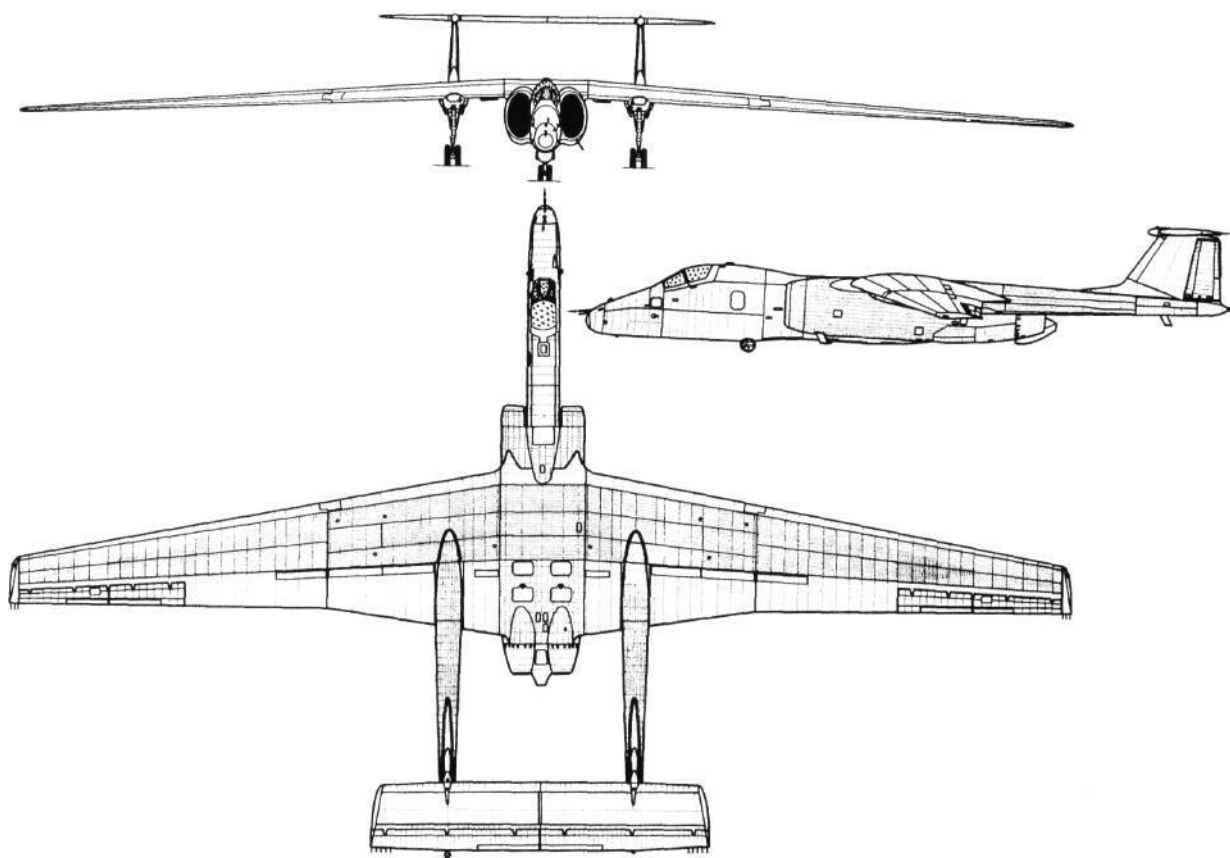
Purpose: To study the ozone layer and perform many other surveillance tasks.

Design Bureau: EMZ named for V M Myasishchev, General Designer V K Novikov.

The M-17 proved so successful in its basically politico-military role that it was decided in 1985 to produce a derived aircraft specifically tailored to Earth environmental studies. The first M-55, No 01552, was first flown on 16th August 1988, the pilot being Nil Merited Pilot Eduard V Chel'tsov who had carried out the initial testing of the M-17. Three further examples were built, Nos 55203/4/5. Further single-seaters, plus the M-55UTS dual trainer, the Geofizka-2 two-seat research aircraft and other derived versions, have been shelved through lack of funds.

Structurally the M-55 was designed to a load factor increased from 2 to 5. This resulted in a new wing which instead of having left/right panels joined on the centre line has inner and outer panels joined to a centre section. Aspect ratio is reduced to 10.7, and aerodynamically the wing retains the P-173-9 profile but has redesigned flaps, ailerons and upper-surface airbrakes. The horizontal tail is modified, with full-span elevator tabs and square tips. The fuel capacity is increased to

M-55



10,375 litres (2,282 Imperial gallons), and range/endurance was further increased by changing to a pair of P A Solov'yov D-30-10V turboprops each rated at 9,500kg (20,944 lb) take-off thrust, and with a combined cruise thrust at 21km (68,898ft) of 670kg (1,477lb). Apart from the landing gear the aircraft was almost totally redesigned, the front of the nacelle being much deeper and more capacious, the engine bays being lengthened, and the flight controls being operated by a dual-channel digital system with manual reversion. In standard form the M-55 carries a payload of up to 1.5 tonnes (3,307 lb), typically comprising a Radius scanning radiometer with swath width of 20km (12.4 miles), a

choice of IR linescanners with swath width of 25km (15.5 miles), an Argos optical scanner with swath width of 28km (17.4 miles), an A-84 optical camera with swath width of 120km (74.6 miles) and a choice of SLARs (sideways-looking airborne radars) with maximum swath width of 50km (starting at 30km and extending to 80km) on each side. Coverage of 100,000km² (38,610 square miles) per hour is matched to an instrumentation transmission rate of 16 Mbits per second.

The EMZ have created a versatile research and geophysical aircraft which is being promoted for such varied tasks as search/rescue, mapping, ozone studies, hailstorm prevention and agricultural monitoring.

| | | |
|--------------------------------|---------------------|----------------------|
| Dimensions | | |
| Span | 37.46m | 122 ft 10% in |
| Length | 22.867 m | 75 ft 1 in |
| Wing area | 131.6m ² | 1,417ft ² |
| Weights | | |
| Empty | 13,995kg | 30,853 lb |
| Maximum take off weight | 23,800kg | 52,469 lb |
| Performance | | |
| Maximum speed | | |
| at 5 km (16,404 ft) | 332 km/h | 206 mph |
| at 20 km (65,617 ft) rising to | 750 km/h | 466 mph |
| Practical ceiling 21,850m | in 35 min | (71,686ft) |
| Endurance | | |
| at practical ceiling | 2hrs 14 min | |
| at a cruise height of 17 km | 6 hrs 30 min | (55,774ft) |
| Max range on direct flight | 4,965km | 3,085 miles |
| Take-off/landing | Similar to M-17. | |

NIAILK-1

Purpose: To build a more efficient light transport.

Design Bureau: NIAI, initials from Scientific Research Aero Institute, Leningrad, formed by the LIIPS, the Leningrad Institute for Aerial Communication; designers AI Lisichkin and V F Rentel.

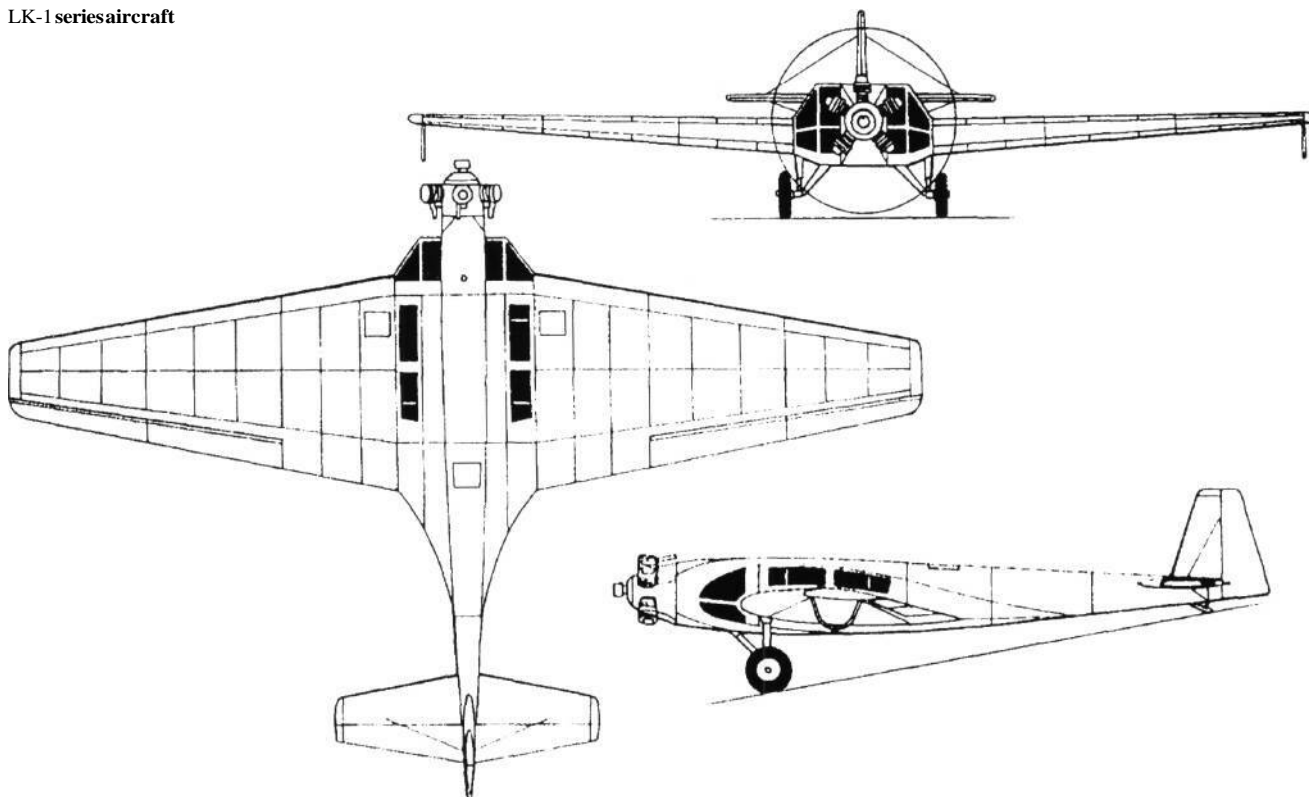
Even though it went into production and everyday use, this aircraft qualifies by virtue of

its extraordinary layout, with the wing blended into the fuselage. The prototype, with civil registration LI 300, was first flown by A Ya Ivanov in May 1933. Despite the fact that the pilot had no view except over a sector of about 100° to the left side, Ivanov's opinion was favourable because the aircraft handled well. After four months of testing in Leningrad the LK-1 was flown to Moscow. There it was tested by the Nil, as a result of which a small

series of 20 were built. These saw Aeroflot service in the Arctic, on occasion being fitted with skis or floats.

LK stood for Leningradskii Kombinat, and the prototype was also unofficially called Fanera-2 (Plywood 2). Though basically a simple all-wood machine, powered by a 100hp M-11 engine, it strove to gain in lift/drag ratio by blending the wing root into the fuselage. Indeed, it could be considered as an all-wing

LK-1 series aircraft



aircraft with the nose engine and rear fuselage attached to the thickened centre wing. This central portion contained two pairs of seats, that on the left in front being for the pilot. The entire front and top of this cabin was skinned in transparent panels, those along the sides sloping at 60°, two of them forming doors. The prototype had a ring-cowled engine, spatted main wheels and a broad but squat fin and rudder. Production aircraft had no cowling or spats, but had a redesigned wing root and a narrower rear fuselage and completely redesigned vertical tail.

Several designers attempted a cabin of this kind, but all the others were very large air-

craft. In fact whether a blended wing/body aircraft can be hyper-efficient is doubtful, though the LK-1 did have useful STOL (short take-off and landing) qualities.

| Dimensions (production aircraft) | | |
|----------------------------------|--------------------|---------------------|
| Span | 12.47m | 40ft 11 in |
| Length | 8.87m | 29 ft Win |
| Wing area | 27.6m ² | 297 ft ² |
| Weights | | |
| Empty | 746kg | 1,645 lb |
| Fuel/oil | 170kg | 375 lb |
| Loaded | 1,160kg | 2,557 lb |
| Performance | | |
| Maximum speed | 154km/h | 96 mph |
| Time to climb 1 km | 10min | (3,281 ft) |
| Service ceiling | 3,370m | 11,000ft |
| Range | 850km | 528 miles |
| Take-off run | 200m | 656ft |
| Landing speed/ run | 65km/h 120m | 40 mph 394ft |

NIAI RK, LIG-7

Purpose: To evaluate an aeroplane with a wing of variable area.

Design Bureau: NIAI, Leningrad.

In 1936 Grigorii (according to Shavrov, Georgii) Ivanovich Bakshayev, aged 18, joined the UK GVF, the instructional combine of the civil air fleet. He was eager to test his belief that a superior aeroplane could be created by arranging for it to have a large wing for take-off and landing and a smaller wing for cruise. As the UK GVF was in Leningrad the NIAI adopted the idea. Called RK (Razdvizhnoye Krylo, extending wing), and also LIG-7 because it was the seventh project of the Leningrad Institute GVF, the aircraft was built quickly and was first flown in August 1937. Remarkably, the

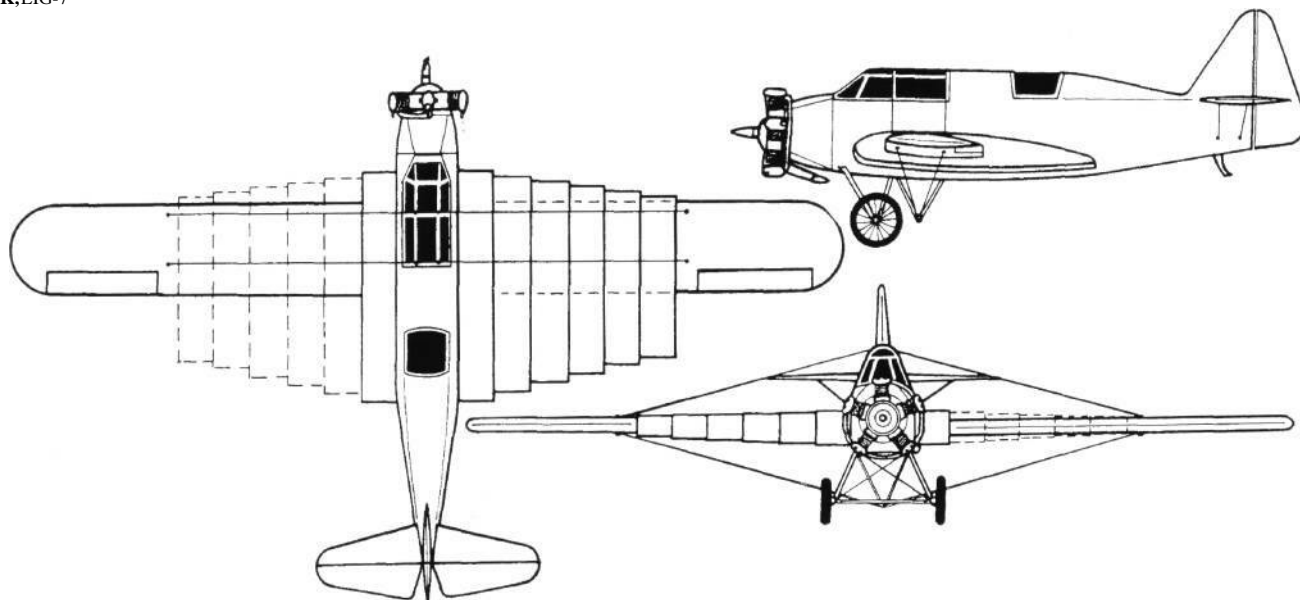
system worked smoothly and reliably (better in the air than on the ground), and it led to the even more unconventional RK-1 fighter.

Apart from the wing the RK was a simple monoplane of mixed construction, with enclosed cockpits for a pilot and observer and powered by an uncowled 100hp M-11 engine driving a laminated-wood propeller. It had a two-spar wing of constant narrow-chord M-6 profile, braced by pairs of wires above and below to the top of the pilot's hood and to a pyramid truss under the fuselage. At the root was what looked like the root section of a much larger wing, with CAHI (TsAGI)-846 aerofoil profile, but with a span of only 50cm (1ft 7in). Inside this, nestling tightly like a set of Russian Matroshka dolls, were five further

plywood wing sections each of 50cm span. The observer could crank these out by a cable mechanism, each adding 45cm (1ft 5in) to the span of the large-chord region. It took 30 to 40 seconds to crank the telescopic sections out to their full extent, covering 60 per cent of the semi-span, and 25 to 30 seconds to wind them back.

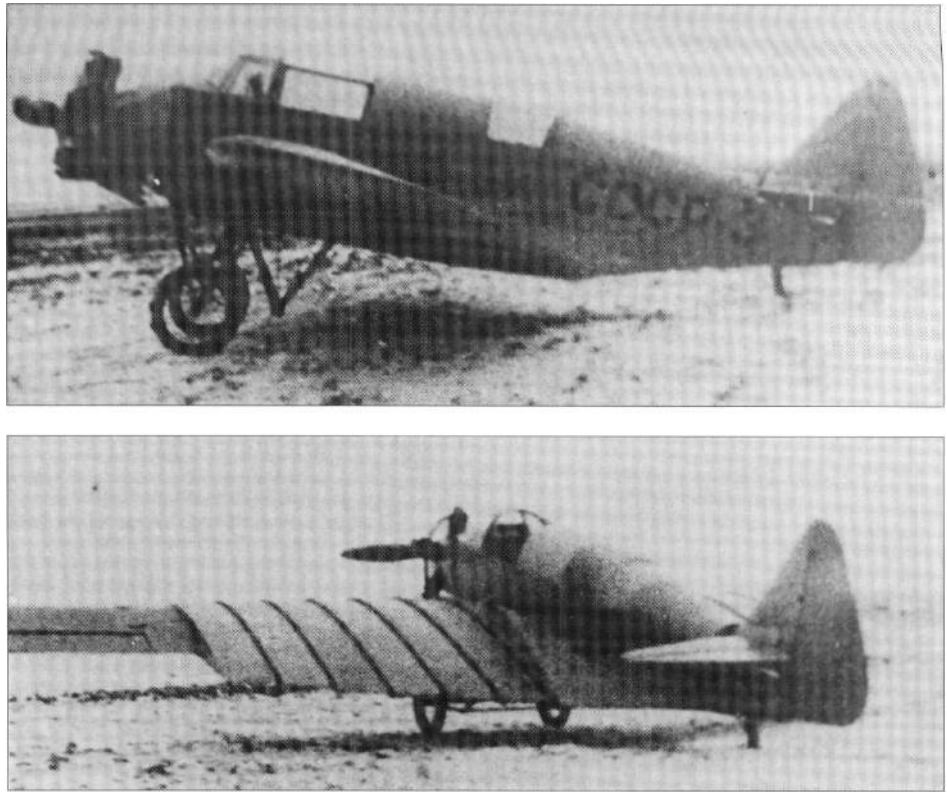
Seemingly a 'crackpot' idea, the RK performed even better than prediction. It is difficult to account for the fact that it got nowhere. The answer must be that it introduced an element of complexity and possible serious danger, sufficient to dissuade any later designer from following suit.

RK, LIG-7



| | | |
|--------------------------|----------------------|------------------------|
| Dimensions | | |
| Span | 11.3m | 37 ft 9 in |
| Length | 7.34m | 24 ft 1 in |
| Wing area (minimum) | 16.56m ² | 178.25ft ² |
| (maximum) | 23.85 m ² | 256.72 ft ² |
| Weights | | |
| Empty | 667kg | 1,470lb |
| Loaded | 897kg | 1,978lb |
| Performance (small wing) | | |
| Maximum speed | 156km/h | 97 mph |
| Time to climb 1,000m | 7.5 min | 3,281 ft |
| to 2,000m | 14.5min | 6,561 ft |
| Service ceiling | 2,900m | 9,514ft |
| Take-off run | 250m | 820ft |
| Landing speed/ | 105km/h | 65 mph |
| run | 210m | 689ft |
| Performance (large wing) | | |
| Maximum speed | 143km/h | 89 mph |
| Service ceiling | 3,100m | 10,171 ft |
| Take-off run | 135m | 443ft |
| Landing speed/ | 68km/h | 42 mph |
| run (both large wing) | 110m | 361ft |

Two views of RK, LIG-7.



NIAI RK-I, RK-800

Purpose: To create a fighter with variable wing area.

Design Bureau: NIAI, Leningrad.

From the start of his telescopic-wing studies young Bakshayev had really been thinking about fighters. He had regarded the RK merely as a preliminary proof-of-concept exercise. He calculated that a fighter able to retract most of its wing area and powered by the M-105 engine ought to be able to reach a world-record 800km/h (497mph), overlooking the fact that a fighter with a relatively small wing would have poor combat manoeuvrability. Indeed, as described below, he found a way to make the relative difference between the small and large wings even greater than in the RK, the ratio of areas being 2.35:1. In October 1938 he submitted a preliminary design sketch for the RK-I (Russian abbreviation for extending-wing fighter). After much argument the concept was accepted by CAHI (TsAGI) and the WS. A one-fifth-scale model was tested in a CAHI (TsAGI) tunnel from January 1939, but it was difficult to find an industrial base capable of building even the prototype. Worse, the RK-I attracted the attention of Stalin, who took a keen interest in combat aircraft. Excited, he demanded that this aircraft should use the M-106 engine, the most powerful then on bench test. Under

some difficulty a prototype RK-I was completed in early 1940, but the M-106 engine (later designated VK-106) was still far from ready. The aircraft could have flown with the M-105, but nobody dared to fit anything but the engine decreed by Stalin. In order to do at least some testing a full-scale model was constructed with the nose faired off, fixed landing gears and a projecting canopy, with no attempt to simulate armament or the radiator ducts in the rear fuselage. This mock-up was then tested in the CAHI (TsAGI) full-scale tunnel. The resulting test report was generally favourable, but noted that sealing between the telescopic wing sections was inadequate. The CAHI (TsAGI) aerodynamicists nevertheless concluded that with the M-106 the speed might be 780km/h (485mph). Lacking an engine the project came to a halt, and after the German invasion in June 1941 it was abandoned. Bakshayev was appointed to supervise increased production of the 156km/h (97mph) U-2 (Po-2) at Factory No 387.

The lifting surfaces of the RK-I were unique, and quite unlike anything attempted by any other designer. The aircraft was all-metal, the large fuselage being a light-alloy monocoque which would have housed the 1,800hp M-106 in the nose with the oil cooler underneath and surrounded by two 20mm ShVAK cannon and two 7.62mm ShKAS machine guns.

Behind the firewall were successively the fuel tanks, backwards-retracting single-strut main landing gears, enclosed cockpit and the glycol coolant radiator with controllable air ducts on each side of the rear fuselage. The amazing feature was that there were two wings of equal span and narrow tapering chord, one in front of the cockpit and the second, set at a slightly lower level, behind. Each had upper and lower skins of spot-welded SOKhGSA stainless steel, and the rear wing was fitted with three hinged trailing-edge surfaces on each side serving as flaps and ailerons. These movable surfaces, like the tail, were made of light alloy. The unique feature was that on this aircraft the root of the large wing extended completely around the front wing and back almost to mid-chord of the rear wing. Nested inside it were 14 further wing profiles, which in 14 seconds could be winched out over the entire span by an electric motor and cable track along the rear wing leading edge, which was at right angles to the longitudinal axis. Each section of the large wing comprised a Dural leading edge and rib with a fabric skin, the first section sealing the side of the fuselage in the high-speed condition and serving as a wing end-plate in the extended low-speed configuration. Shavrov gives the weight of all 28 telescopic sections as approximately 330kg (727.5lb). Changing

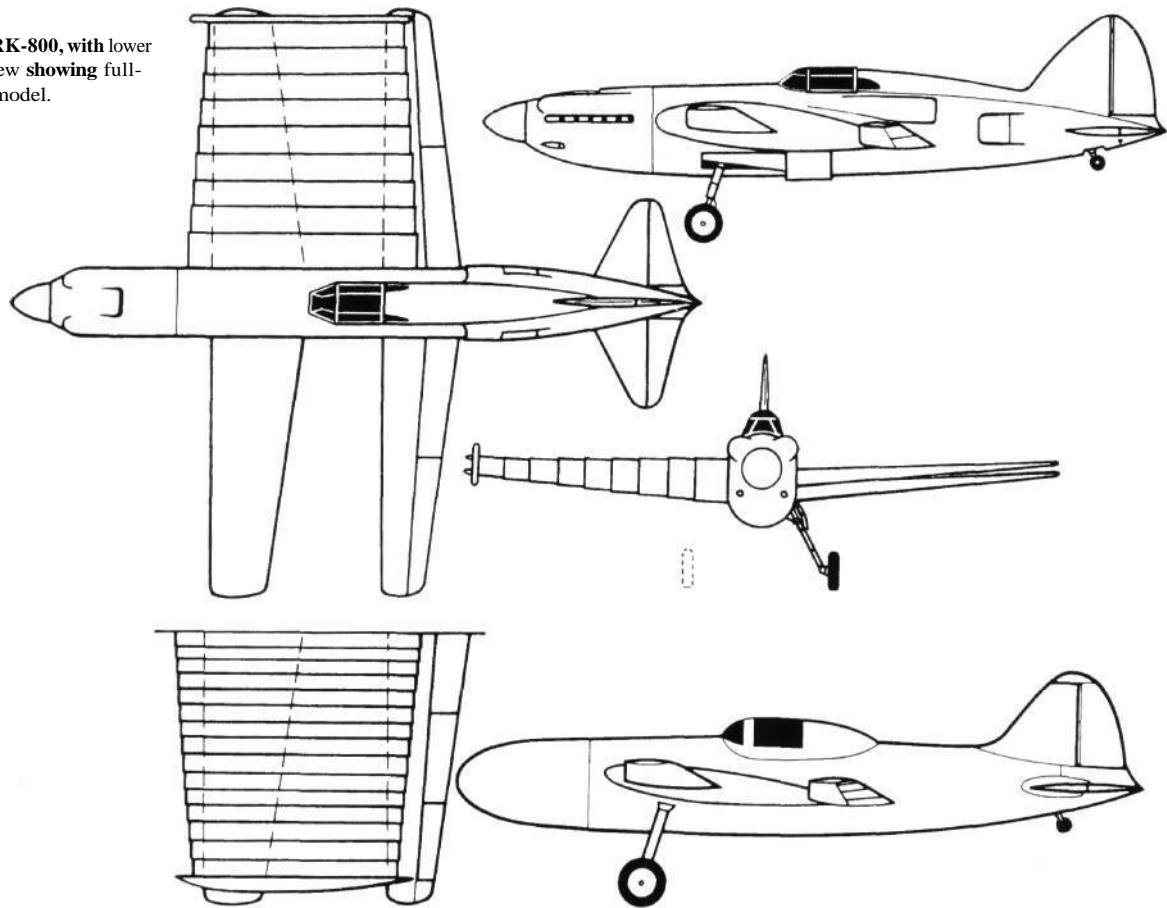
to the large-area configuration was intended to have no significant effect on the rod-operated flight controls, a fact confirmed by CAHI (TsAGI). Bakshayev left drawings showing that a production aircraft would have had only nine larger telescopic sections, and various other changes.

Had an M-106 engine been available this aircraft might have flown. Pilots would then have been able to assess whether (as seems doubtful) the ability to fly with much less wing

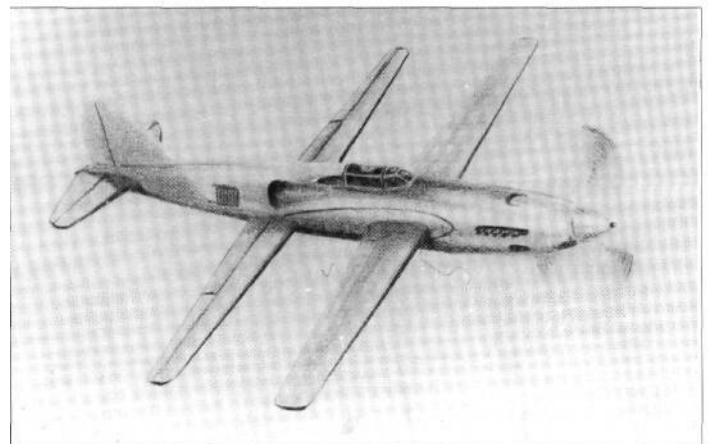
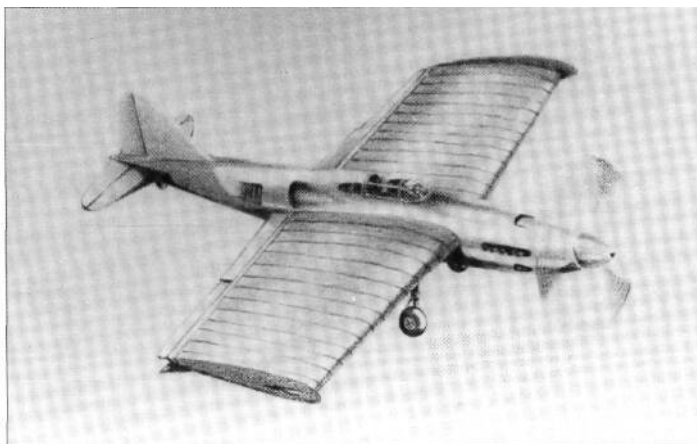
area than needed for take-off and landing really offered any advantage to an aircraft designed to engage in close combat.

| Dimensions | | |
|----------------------------|--------------------|---------------------------|
| Span | 8.2m | 26 ft 10 $\frac{1}{2}$ in |
| Length | 8.8m | 28 ft 10 $\frac{1}{4}$ in |
| Wing area (large) | 28.0m ² | 301 ft ² |
| (small) | 11.9m ² | 128ft ² |
| Weights | | |
| Empty | not recorded | |
| Loaded (estimate) | 3,100kg | 6,834 lb |
| Performance (estimated) | | |
| Max speed (small wings) | 780 km/h | 485 mph |
| Endurance | 2 hrs 27 min | |
| Landing speed (large wing) | 115 km/h | 71.5 mph |

RK-I, RK-800, with lower side view showing full-scale model.

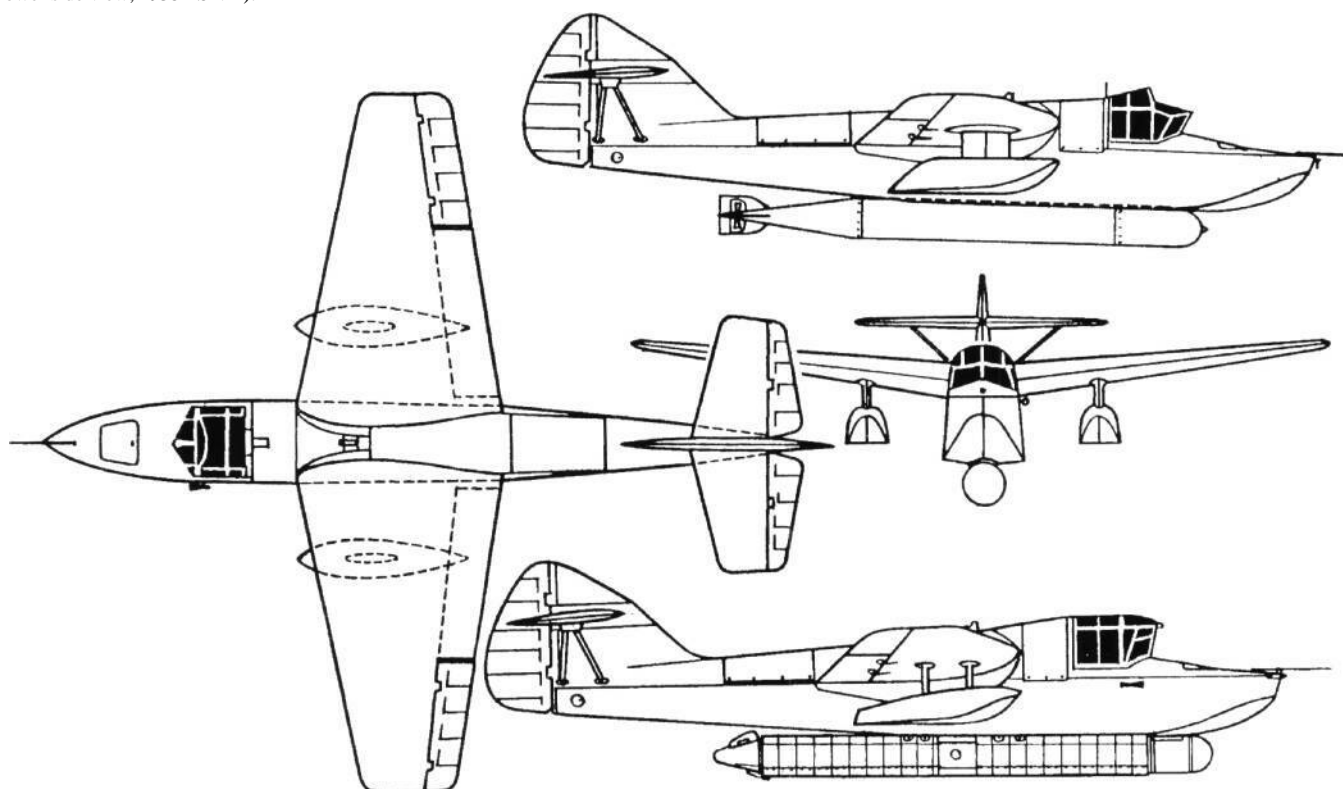


Sketches of RK-I showing its two configurations.



Nikitin PSN

Original 1936 version of **PSN**
(lower side view, 1938 PSN-1).



Purpose: A series of air-launched experimental gliders intended to lead to air-to-surface missiles.

Design Bureau: Initially OKB-21, later OKB-30, chief designer **NG** Mikhel'son, later **VV** Nikitin.

In 1933 **S F** Valk proposed the development of a pilotless air-launched glider with an autopilot, infra-red homing guidance and large warhead for use as a weapon against ships, or other major heat-emitting targets. From 1935 this was developed in four versions which in 1937 were combined into the **PSN** (from the Russian abbreviation for glider for special purposes). At this stage chief designer was Mikhel'son (see previous entry on **MP**). The concept was gradually refined into the PSN-1, of which a succession of ten prototypes were launched from early 1937 from under the wings of a TB-3 heavy bomber. By 1939 the totally different PSN-2 was also on test. Also designated TOS, these were initially dropped from the TB-3 and later towed behind a TB-7 and possibly other aircraft. In each case the glider was to home on its target at high speed after release from high altitude.

The PSN-1 was a small flying boat, with stabilizing floats under the high-mounted wing.

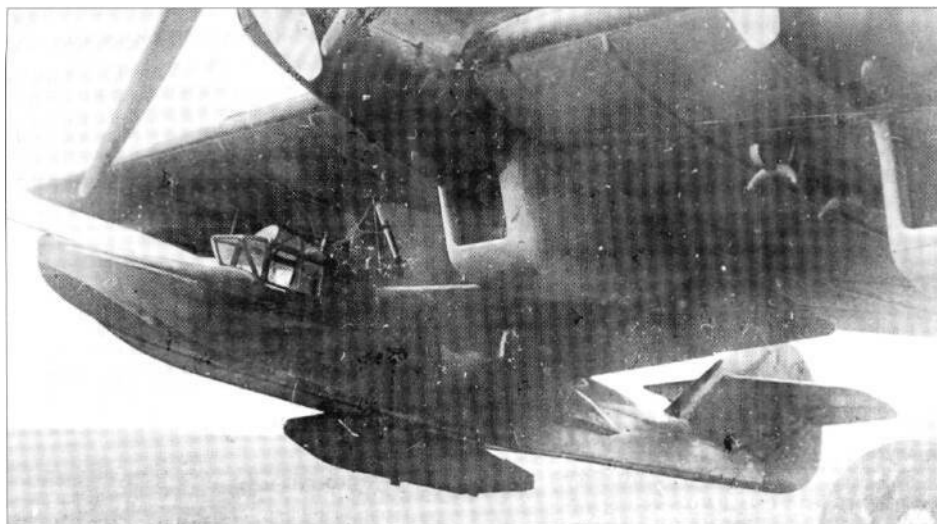
It had a cockpit in the nose, where in the planned series version the warhead would be. In the DPT version the payload was a 533mm (1ft 9in) torpedo hung underneath. Once the basic air vehicle had been perfected the main purpose of flight testing was to develop the Kvant (quantum) infra-red guidance. In contrast the PSN-2 was a twin-float seaplane with a slim fuselage, low wing and a large fin at the rear of each float. This again was flown by human pilots to develop Kvant guidance. After release from the parent aircraft the manned gliders made simulated at-

tacks on targets before turning away to alight on the sea. The planned pilotless missiles were intended to be expendable, and thus had no need for provisions for alighting.

Neither of the PSN versions made it to production, these projects being stopped on 19th July 1940. In retrospect they appear to have been potentially formidable.

Two PSNs afloat.





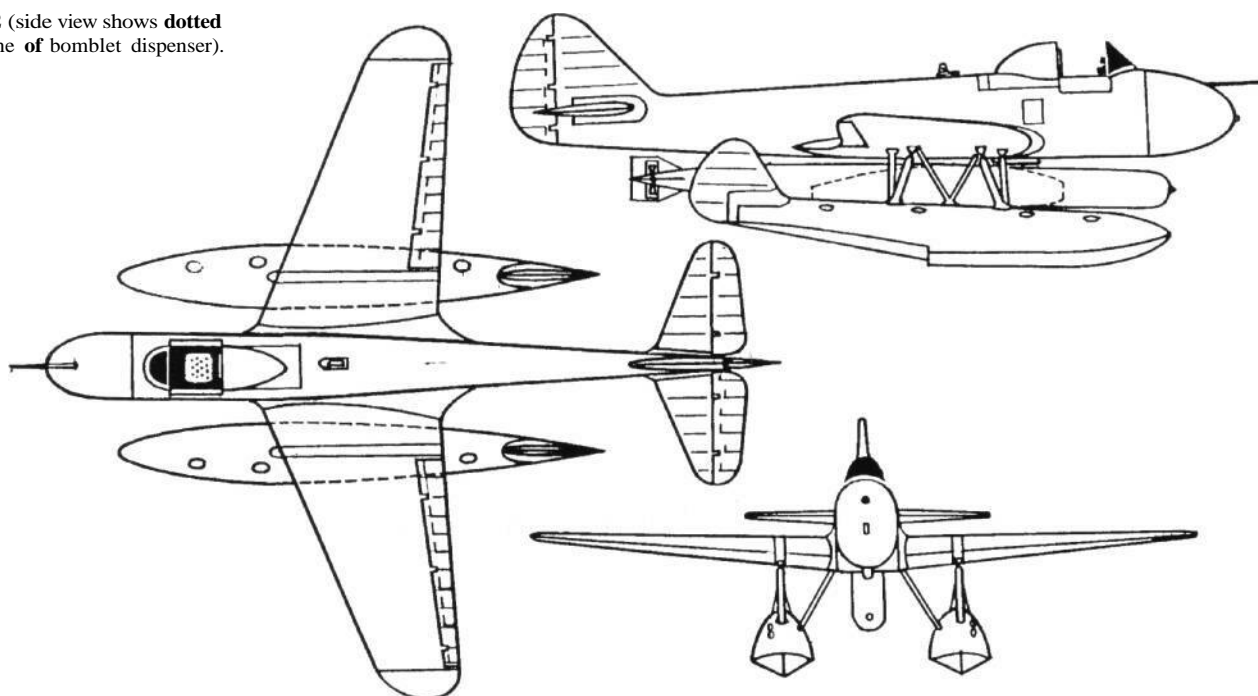
Dimensions (piloted versions)

| | | |
|---|----------|-------------|
| PSN-1 | | |
| Span | 8.0m | 26 ft 3 in |
| Weight empty | 970kg | 2,138 lb |
| Payload | 1 tonne | 2,205 lb |
| PSN-2 | | |
| Span | 7.0m | 22 ft UK in |
| Length | 7.98m | 26 ft 2 in |
| Design mission of pilotless version 40 km (25 miles) at | 700 km/h | 435 mph |

Left: PSN-1, with bomblet container, under wing of TB-3.

Bottom: PSN-2 without payload.

PSN-2 (side view shows **dotted** outline of bomblet dispenser).



Nikitin-Shevchenko IS-1

Purpose: To create a fighter able to fly as a biplane or monoplane.

Design Bureau: OKB-30, Chief Designer V V Shevchenko.

There is some dispute over who was responsible for the experimental IS fighters. Generally ascribed to VV Nikitin, in more recent accounts he is hardly mentioned and all credit is given to Shevchenko who is quoted as saying 'IS stands for Iosif Stalin'. In fact, though the conception was indeed Shevchenko's, he was an NII-WS test pilot who was occasionally employed by Nikitin. Design of the IS series was carried out in partnership with Nikitin, and IS actually meant Istrebitel Skladnoi, folding fighter. Surprisingly, it was also given the official GUAP designation I-220, even though this was also allocated to a high-altitude MiG fighter. The idea was that the aircraft should take off as a biplane, with a short run, and then fold up the lower wing underneath the upper wing in order to reach high speed as a monoplane. Shevchenko promoted the idea in November 1938, getting an enthusiastic response, and therefore in 1939 demonstrated a detailed working model built at the Moscow Aviatekhnium (MAT). His project captivated Stalin and Beria, who wanted the aircraft flying in time for the October Revolution parade in November 1939. Shevchenko was given 76 million roubles and

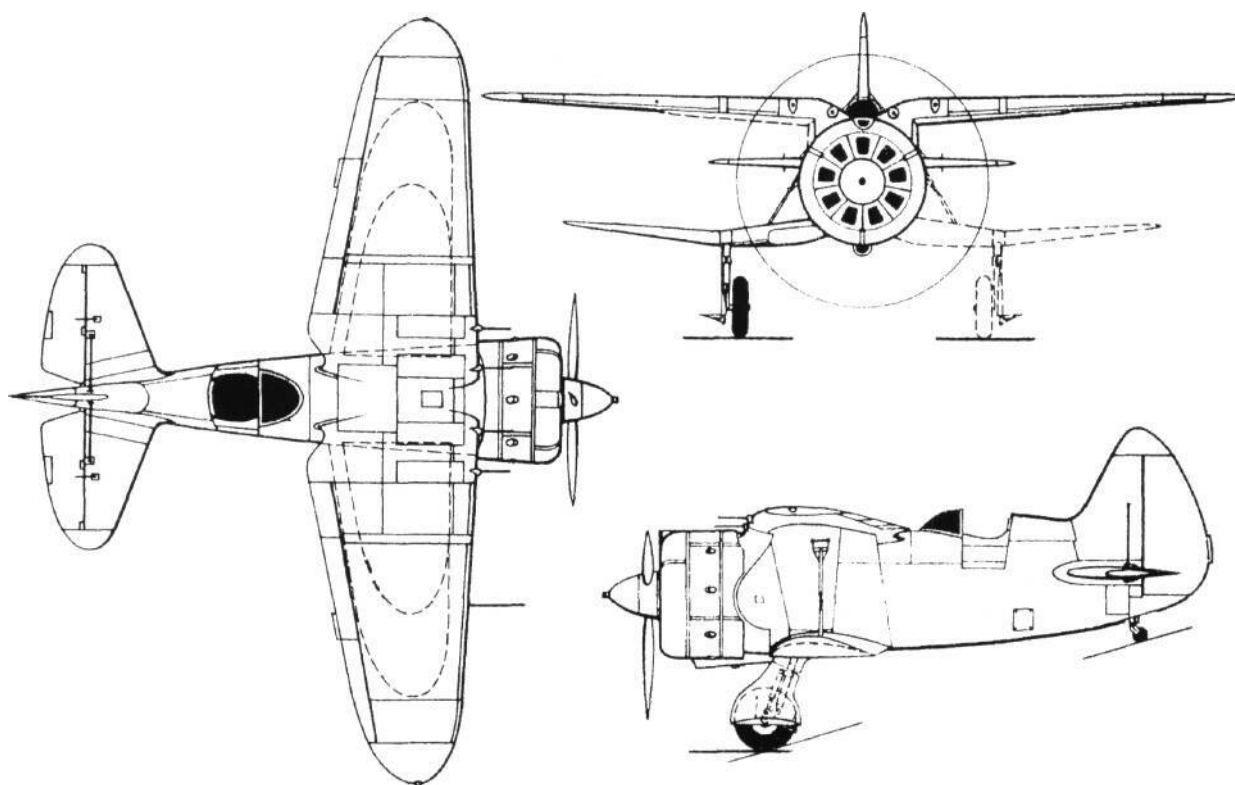


facilities at Factory No 156, while the OKB-30 design team eventually numbered 60. The IS-1 was first flown by V Kuleshov on 29th May 1940, and the lower wings were first folded by G M Shiyonov on 21st June 1940. Shevchenko states that Shiyonov carried out LII testing and completed his report on 9th January 1941. According to Shevchenko, glowing accounts were also written by such famous test pilots as Suprun and Grinchik. In fact, Shavrov records that 'State tests were considered unnecessary, as the maximum speed was only 453km/h'. As it was so much slower than the LaGG, MiG and Yak fighters, this aircraft was

put into storage after the German invasion, together with the IS-2.

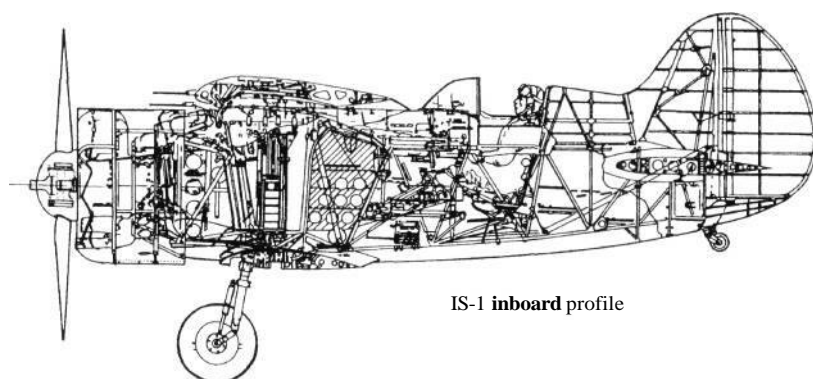
As far as possible the IS-1 resembled the existing production fighter, the I-153. It had the same 900hp M-63 engine, driving a Hamilton VISH propeller of 2.8m (9ft 2in) diameter, and apart from the extra 'wing fold' lever the cockpits were identical. The airframe was all-metal, the fuselage framework being welded SOKhGSA steel tube, with removable metal panels to the front of the cockpit and fabric aft, while each wing had similar construction for the two spars, but DIG light-alloy ribs and flush-riveted DIG skins. The tail was DIG with

IS-1



fabric covering. After take-off the pilot selected 'chassis up', folding the main landing gears inwards by the 60-ata (882 lb/in²) pneumatic system. He could then select 'wing fold', whereupon a pneumatic ram and hinged levers on each side folded the lower wing. The inboard half was then recessed into the fuselage and the hinged outer half (which remained horizontal throughout) was recessed into the upper wing to complete its aerofoil profile. The planned armament was four ShKAS in the inner gull-wing part of the upper wing. There was no cockpit armour.

Though it may have seemed a good idea, the realization was a disappointment. Apart from the overall inferiority of the IS-1's performance, it was nonsense to reduce wing area in an aircraft needing the maximum possible combat agility, and moreover to try on the one hand to increase wing area for take-off



IS-1 inboard profile

and landing whilst simultaneously leaving half the upper (main) wing with a huge hollow on the underside which destroyed the aerofoil profile. A detail is that with the wings

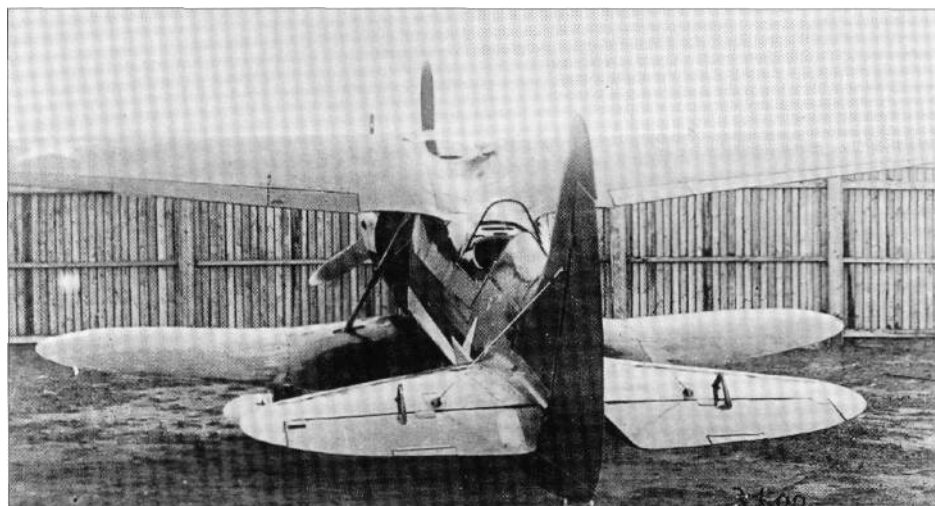
folded there was nowhere for spent cartridge cases to escape.

Previous page and below: Views of IS-1.

| | | |
|------------------------|----------------------|---------------------|
| Dimensions | | |
| Span (upper) | 8.6m | 28 ft 7 in |
| (lower, extended) | 6.72m | 22 ft 4 in |
| Length | 6.79m | 22 ft 3 in |
| Wing area (as biplane) | 20.83 m ² | 224 ft ² |
| (upper only) | 13.0m ² | 140ft ² |

| | | |
|---------|---------|----------|
| Weights | | |
| Empty | 1,400kg | 3,086lb |
| Loaded | 2,300kg | 5,070 lb |

| | | |
|------------------------------|---------|-----------|
| Performance | | |
| Maximum speed | 453km/h | 281 mph |
| Time to climb 5 km | 5.0 min | 16,404ft |
| Service ceiling (as biplane) | 8,800 m | 28,870 ft |
| Range | 600km | 373 miles |
| Take-off run (biplane) | 250m | 820ft |
| Landing speed (biplane) | 115km/h | 71.5 mph |



Nikitin Shevchenko IS-2

Purpose: Improved version of IS-1

Design Bureau: OKB-30, chief designer V V Shevchenko

The initial funding allocated to Shevchenko's project actually paid for two prototypes. Though construction of both began in parallel it was soon decided to incorporate improvements in the dubler (second aircraft). Designated IS-2, and also known as the I-220t/s, this emerged from GAZ No 156 in early 1941. Surviving documents differ. One account states that the IS-2 'was ready in January 1941...the War broke out and only four test flights were carried out.' Three other accounts, in Russian, French and English, state that the aircraft was completed in April 1941 but had not flown when the Germans invaded. Shavrov is non-committal, but notes that all performance figures are estimates. The

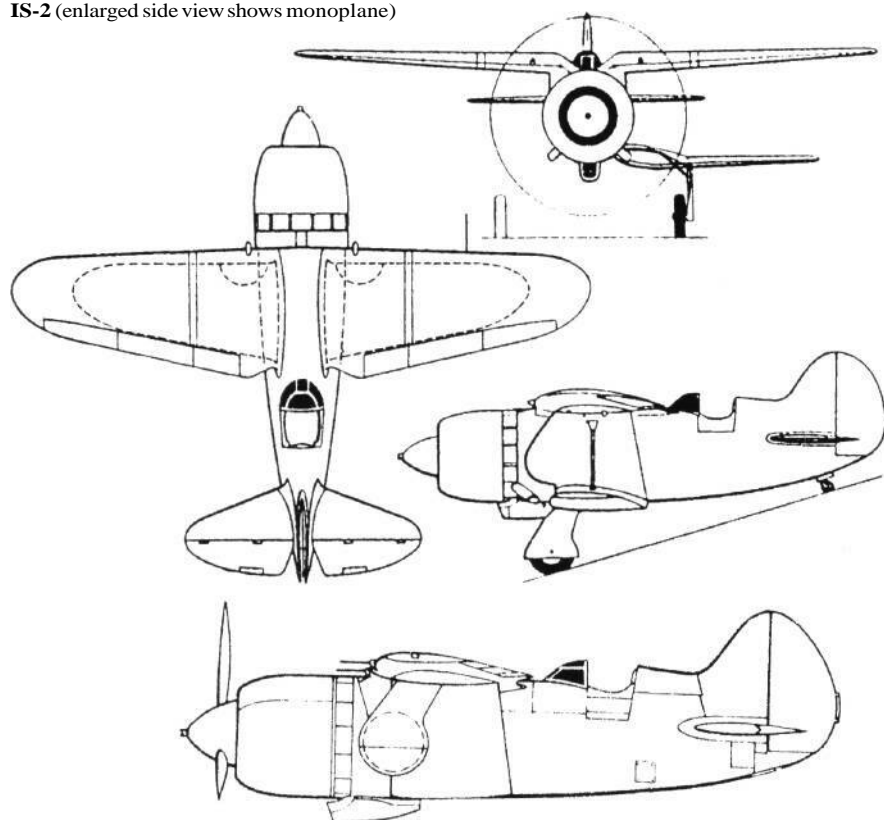
walk-round outdoor photos were all taken with snow on the ground.

The IS-2 was a refined derivative of the IS-1. The engine was an M-88 14-cylinder radial rated at 1,100hp, neatly installed in a long-chord cowl with a prominent oil-cooler duct underneath and driving a VISH-23 propeller with a large spinner, but retaining Hucks starter dogs. According to Podol'nyi, the fuselage cross-section was reduced (which is certainly correct) and, while wing spans remained the same, chord was reduced in order to increase aspect ratio and reduce area. Shavrov and a French author state that the wings of the IS-1 and IS-2 were geometrically identical. What certainly was altered was that the landing-gear retraction system was replaced by simply connecting the main legs to the wing linkage, so that a single cockpit lever and a single pneumatic jack folded

the lower wings and the main landing gears in a single movement. It is widely believed that the IS-2 was not intended to fly in combat as a biplane, the benefits being restricted to take-off and landing. In the IS-1 documentation the idea that the aircraft might be operated as a biplane is never mentioned. If it were, then what was the point of the folding lower wing? Further modifications in the IS-2 were that the tail was redesigned, the tailwheel could retract and the two inboard ShKAS were replaced by heavy 12.7mm Beresin BS guns.

By the time this aircraft appeared, even though it looked more modern than its predecessor, the WS was fast re-equipping with simple monoplane fighters. These unquestionably stood more chance against the Luftwaffe than the IS-2 would have done.

IS-2 (enlarged side view shows monoplane)



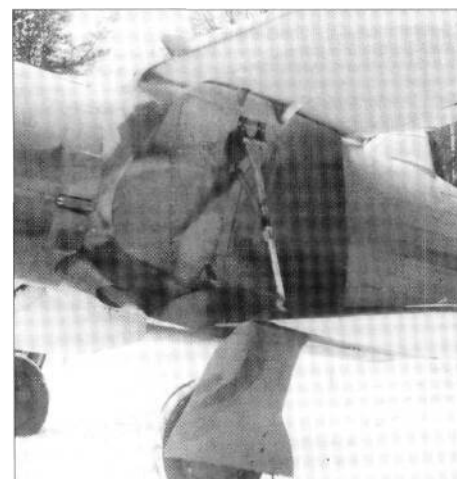
| | | |
|------------------------|----------------------|---------------------|
| Dimensions | | |
| Span (upper) | 8.6 m | 28ft 7in |
| (lower, extended) | 6.72 m | 22 ft 4 in |
| Length | 7.36 m | 24 ft 5 in |
| Wing area (as biplane) | 20.83 m ² | 224ft ² |
| (upper only) | 13.0m ² | 140 ft ² |

Weights

Loaded, Shavrov's 'estimated 2,180 kg'
is probably a misprint for 2,810kg 6,195 lb

Performance (estimated)

Shavrov's speed of 588 km/h and ceiling of 1,100 m are suspect, and Podol'nyi's '600 km/h' is even less credible; the only plausible figure appears to be the 507 km/h (315 mph) of the French account.



Views of IS-2.

Nikitin Shevchenko IS-4

Purpose: This was intended to be the ultimate biplane/monoplane fighter.

Design Bureau: OKB-30, chief designer VV Shevchenko

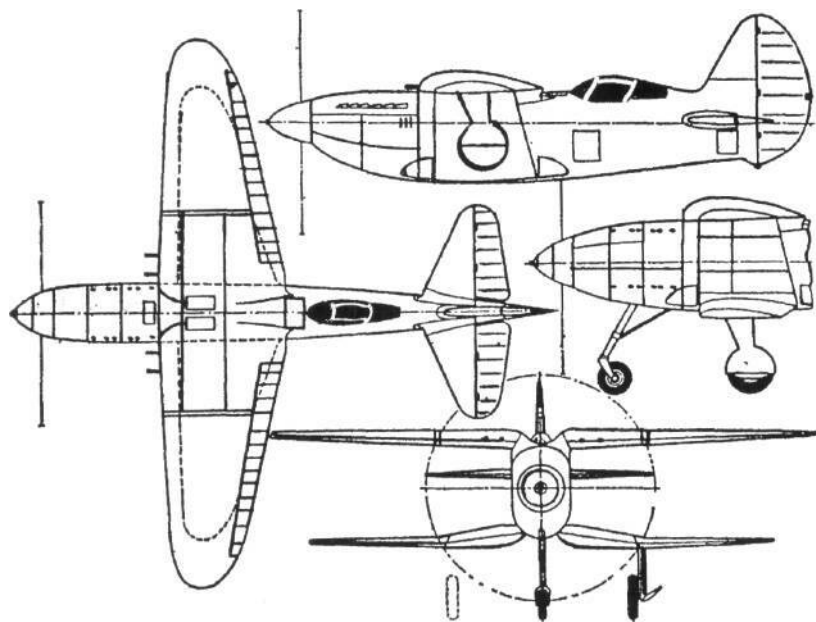
Dismissed by Shavrov in a single line, the IS-3 and IS-4 were the last of Shevchenko's convertible biplane/monoplane projects. No IS-3 documents have been found, but brief details and a three-view drawing exist of the IS-4. Unlike its predecessors, this was a 'clean sheet of paper' aircraft, an optimised fuselage fitted with shutters to cover the retracted lower wing and landing gear. The latter was of the nosewheel type, the cockpit was en-

closed, and armament was to be the same as the IS-2. The engine selected was Klimov's M-120, with three six-cylinder cylinder blocks of VK-105 type spaced at 120°, rated at 1,800hp. When it was clear that this engine would not be ready Shevchenko reluctantly switched to the equally massive AM-37 Vee-12, rated at 1,380hp. In about 1942 he revised the IS-4 so that it would have been powered by a 2,000hp M-71F radial, and would have been fitted with slats on the upper wing to eliminate tail buffet. No photographs of the IS-4 have been found, though two documents insist that it was built and one even states that it flew.

Little need be added, beyond the report that, despite the considerable increase in weight over the previous IS fighters, the wings were smaller. Even with slats it is difficult to see how the landing speed could have been slower. In the conditions prevailing during the War it is stretching credulity to believe that this aircraft could have been built.

Shevchenko persisted with his biplane/monoplane idea too long. His last project was the IS-14 of 1947, a jet with monoplane wings which not only were pivoted to vary the sweepback up to 61° but could also (by means unstated) vary the span.

IS-4 (side view shows monoplane, inset shows biplane with M-120 engine).



Dimensions (estimated for final form, with M-71F engine)

| | | |
|---------------------|--------------------|--------------------|
| Span (upper) | 7.5m | 24 ft 7 1/4 in |
| (lower) | 5.6m | 18 ft 4 1/4 in |
| Length | 8.28m | 27 ft 2 in |
| Wing area (biplane) | 18.0m ² | 194 ff |
| (upper wing only) | 10.0m ² | 108ff ² |

Weights

| | | |
|--------|---------|----------|
| Empty | 2,140kg | 4,718 lb |
| Loaded | 3,100kg | 6,834 lb |

Performance

| | | |
|-----------------------|---------|----------|
| Max speed (monoplane) | | |
| at sea level, | 660km/h | 410 mph |
| at 6.0 km (19,685 ft) | 720km/h | 447 mph |
| minimum flying speed | 107km/h | 66.5 mph |

OOS Stal'-5

Purpose: Flying-wing transport or bomber.

Design Bureau: OOS, Russian for Section for Experimental Aeroplane Construction, Moscow Tushino.

Along with Kozlov (see 'invisible aircraft' story) the chief designer at OOS was Aleksandr Ivanovich Putilov, who joined from CAHI (TsAGI) when OOS was just a group in-

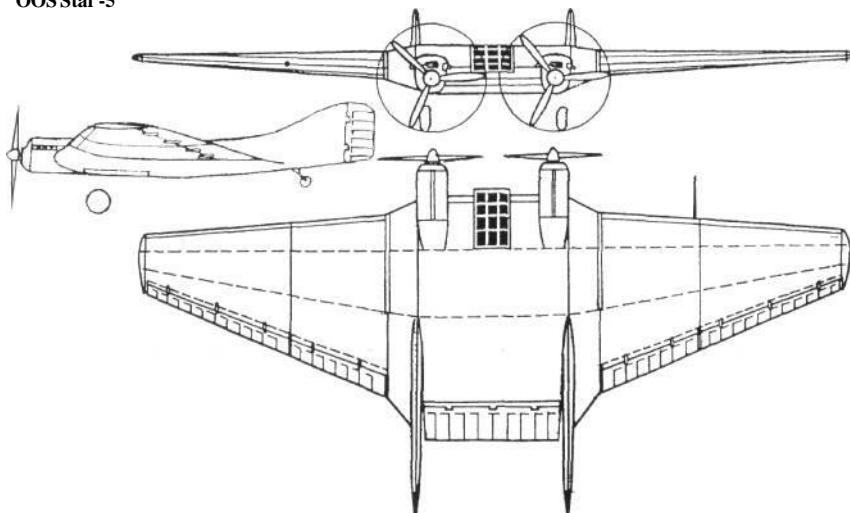
terested in steel airframes. The Stal' (steel) 5 was sketched in 1933 in two forms, as a transport and also as the KhB (Khimicheskii Boyevik), an attack aircraft for spraying poison gas (obviously it could also carry bombs). In 1934 a complete wing spar was made for static test, and in late 1935 VVKarpov and Ya G Paul actually flight-tested a scale model with a span of 6m (19ft 7in), wing area of

15.0m² (161.5ft²) and two 45hp Salmson engines. It was difficult to fly, and the idea was dropped.

Putilov's flying wing was to be powered by two 750hp M-34F water-cooled V-12 engines. The structure was to have been almost entirely Enerzh-6 stainless steel, skinned with Bakelite-bonded veneer over the centre section and fabric elsewhere. The drawing shows the slotted flaps, elevator and four retractable wheels. The payload was to have been between the spars in the centroplan (centre wing), deep enough for people to walk upright.

Several designers, notably the American Burnelli, tried to make extra-efficient aircraft along these lines. None succeeded.

OOS Stal'-5



Dimensions

| | | |
|-----------|-------|----------------------|
| Span | 23.0m | 75 ft 5 1/8 in |
| Length | 12.5m | 41 ft |
| Wing area | 120mf | 1,292ft ² |

Weights (estimated)

| | | |
|--------|------------|-----------|
| Empty | 5.5 tonnes | 12,125 lb |
| Loaded | 8 tonnes | 17,640 lb |

No other data.

Petlyakov Pe-2 experimental versions

Purpose: To test various items on modified Pe-2 aircraft.

Design Bureau: Basic aircraft, '100' in special prison CCB-29 (TsKB-29), later VM Petlyakov's own OKB.

Production of this outstanding fast tactical bomber totalled 11,427. One of the experimental wartime versions was the Pe-2Sh (Shturmovik, assaulter) with various combinations of 20mm ShVAK cannon and 7.62mm ShKAS either firing ahead from a gondola or installed in one or more batteries firing obliquely down from what had been the fuselage bomb bay. The Pe-2VI and Pe-2VB were

special high-altitude versions with pressurized cabins and VK-105PD engines with two-stage superchargers. The Pe-2RD was fitted with a Dushkin/Glushko RD-1 or RD-1KhZ rocket engine installed in the tailcone, with the tanks and control system in the rear fuselage. This aircraft was tested in 1943 by Mark L Gallai. Like the similarly modified Tu-2, the Pe-2 Paravan (paravane) had a 5m (16ft Sin) beam projecting ahead of the nose from the tip of which strong cables led tightly back to the wingtips. While the Tu-2 had a tubular beam, that of the Pe-2 was a truss girder, and the balloon cables struck by the wires were deflected further by large wingtip rails. From

1945 one Pe-2, as well as at least one Tu-2, was used by CIAM and Factory No 51 to flight test a succession of pulsejet engines beginning with captured German Argus 109-014 flying-bomb units. Test engines were mounted above the rear fuselage, with fuel fed by pressurizing the special aircraft tank to 1.5kg/cm^2 (21.31lb/in^2). In 1946-51, under VN Chelomey, Factory 51 improved this German pulsejet into a succession of engines designated from D-3 to D-14-4. All the early models were tested on the Pe-2, despite fatigue caused by the severe vibration.

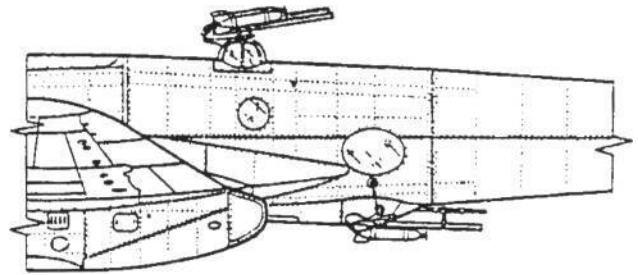


Top left: **Twin ShVAK-20 cannon in Pe-2Sh** (two more were further back).

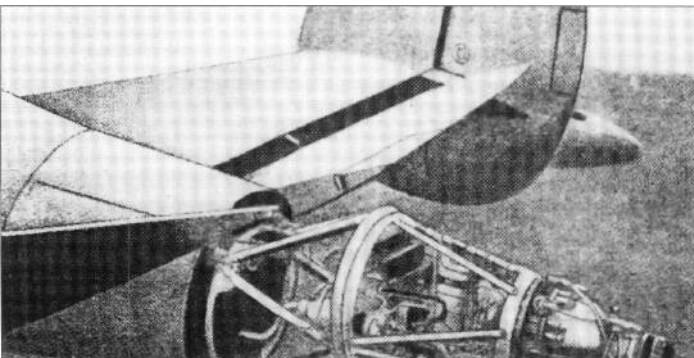
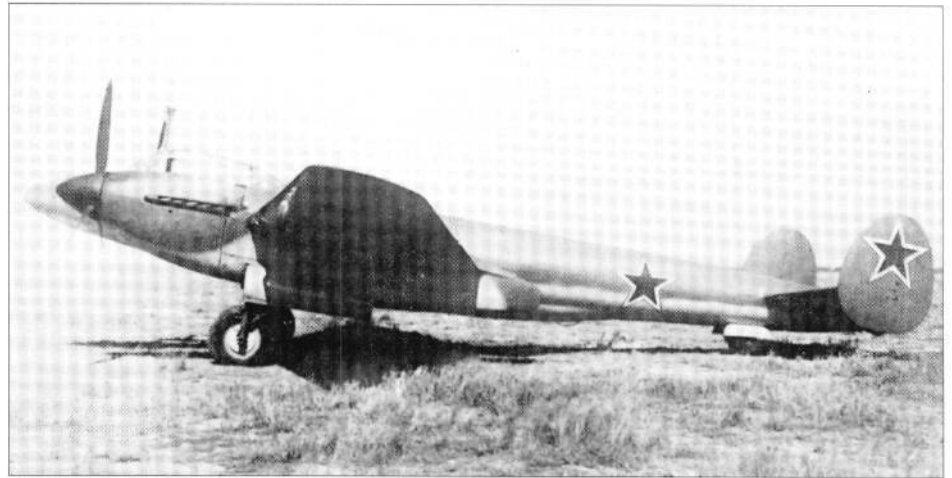
Right: Pe-2VI.

Below left: **Pe-2RD** (rocket engine fairing removed).

Below right: Pe-2 testing 109-014 pulsejet.



Rear defence by aft-firing RO-82 rockets:
RUB-2L dorsal and RUB-4 ventral.



Petlyakov Pe-8 experimental versions



Purpose: To test various items on modified Pe-8 aircraft.

Design Bureau: Originally sub-group KB-1 within special design bureau KOSOS, created in 1935 to manage the ANT-42 (ANT from Andrei N Tupolev). Prototype built at GAZ No 156, the special factory at the secure NKVD site where aircraft designers were imprisoned. Petlyakov was rehabilitated in July 1940 and made General Constructor of his own OKB until he was killed in a Pe-2 on 12th January 1942.

First flown on 27th December 1936, the ANT-42 was redesignated Pe-8 for its lead designer during 1943. Though built only in modest numbers, this heavy bomber was by that time in service in versions powered by the AM-35A, the M-30, M-40 and ACh-30B diesels and the ASH-82 radial. Because of the small numbers only a handful were available for experimental work, but the work they did was varied. One of the final batch of four, designated Pe-8ON (Osobogo Naznacheniya, special assignment) and originally built as long-range VIP transports, was used to test a range of special equipment for use in Polar regions, including nav aids able to operate at 90° latitude and long-range voice communications. Using various engines, Pe-8 bombers tested a range of new designs of propeller, including types

later used for turboprops. At least three aircraft served CIAM and various engine KBs as engine test-beds, ten types of experimental engine being mounted on the wings, on the nose or under the bomb bay.

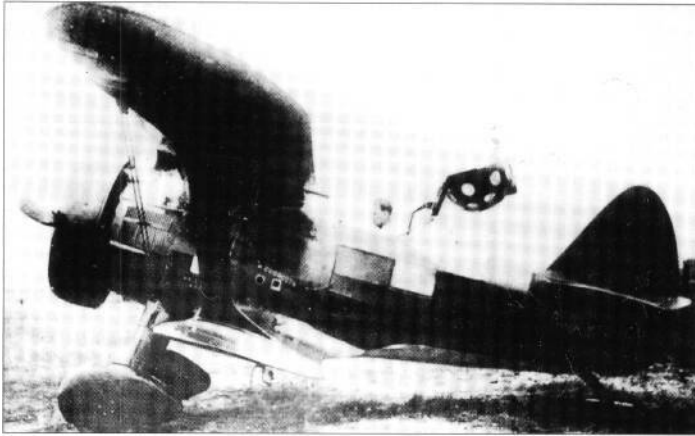
The Pe-8 was also important in the development of many types of bomb and other air-launched weapon. Such work culminated in the testing of captured German FiLOS ('V.I') flying bombs and of the Soviet cruise missiles derived from it. Unlike the Germans, the MVS (ministry of weapons) decided that all the earliest trials should be of the air-launched versions. Launching equipment was produced at GAZ No 456 (General Constructor IV Chetverikov, see earlier), and GAZ No 51 produced three sets of pylons matched to the Pe-8. The only other possible carrier of the original single-engined missile was the Yer-2, but the Pe-8 was preferred because of its greater load-carrying ability and flight endurance. Initially 63 German missiles were launched on the Dzhisak range near Tashkent between 20th March and late August 1945. In 1946 two more Pe-8 bombers were taken from store at GAZ No 22 (the original Tupolev production plant at Kazan) and modified to carry the improved IOKh (written IOX in Cyrillic). Assisted by GAZ No 125 at Irkutsk, Factory No 51 produced 300 of this version, and 73 were tested from the Pe-8s

Top left: Pe-8 with ACh-30B diesel engines testing ASH-21 on the nose.

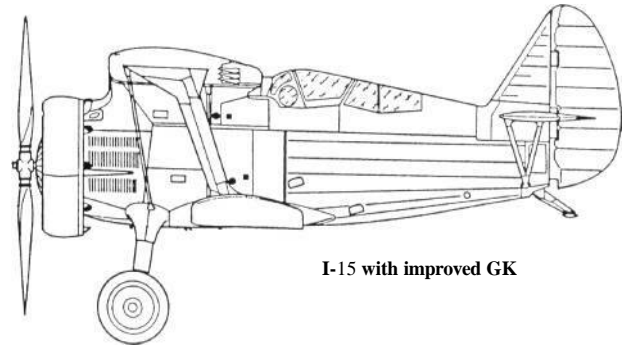
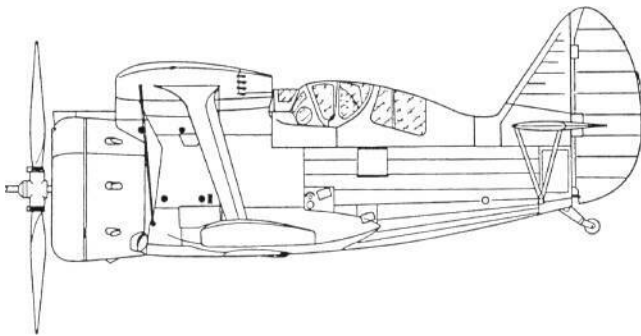
Top right and above: Two views of Pe-8 (ASH-82 engines) launcher for IOKh flying bombs.

between 15th December 1947 and 20th July 1948. Most had speed increased from 600 to 800km/h (497mph) by fitting the D-5 pulsejet engine, and nearly all had wooden wings. In parallel the 14Kh was produced, with the D-5 engine and tapered wings, ten being tested from Pe-8s between 1st and 29th July 1948. The final variant was the 16Kh Priboi (breakers, surf), and though this could be launched from a Tu-2 the Pe-8 remained the principal carrier. This version had twin D-14-4 engines, twin fins, precision radar/radio guidance and a speed of 858km/h, later raised to 900km/h (559mph). It was tested by the Pe-8, Tu-2 and Tu-4, but never entered service.

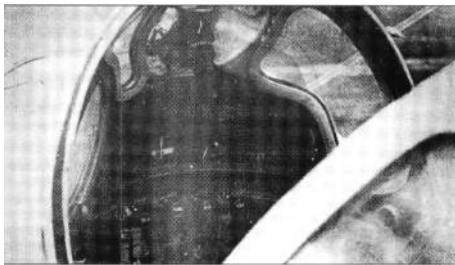
Polikarpov I-15 and I-153 with GK



I-153V



I-15 with improved GK



Purpose: To test pressurized cockpits.

Design Bureau: OSK (Department for Special Construction), Moscow, lead designer Aleksei Yakovlevich Shcherbakov, and Central Construction Bureau (General Designer NN Polikarpov) where Shcherbakov also worked.

In 1935 Shcherbakov was sent to OSK to specialize in the problems of high-altitude flight. He concentrated on the detailed engineering of pressurized cockpits, called GK (Germeticheskaya Kabina, hermetic cabin). By this time the BOK-1 had already been designed and was almost ready to fly, but Shcherbakov did not spend much time studying that group's difficulties. His first GK was tested on SP Korolyov's SK-9 sailplane, predecessor of the RP-318 described previously. The second was constructed in a previously built Polikarpov I-15 biplane fighter. Polikarpov's biplane fighters were noted for their outstanding high-altitude capability, and from 1938 Shcherbakov spent most of his time as Polikarpov's senior associate. The modified aircraft first flew in 1938. Later in the same year an I-15 was tested with a very much better GK. In 1939 the definitive GK was tested on an I-153, an improved fighter whose design was directed by Shcherbakov. The test-bed aircraft was designated I-153V (from Vysotnyi, height). This cockpit formed the basis for those fitted to MiG high-altitude fighters, beginning with the 3A (MiG-7, I-222). Later Shcherbakov managed GK design for four other OKBs, and from 1943 created his own aircraft at his own OKB.

No details have been discovered of the first GK, for the SK-9, and not many of the second, fitted to an I-15 with spatted main landing gear. Like other aircraft of the 1930s, the I-15 fuselage was based on a truss of welded KhMA (chrome-molybdenum steel) tubing, with fabric stretched over light secondary aluminium-alloy structure. Accordingly, Shcherbakov had to build a complete cockpit shell inside the fuselage, made of thin light-alloy sheet. He had previously spent two years studying how to seal joints, and the holes through which passed wires to the control surfaces and tubes to the pressure-fed instruments. On top was a dome of duralumin,

hinged upwards at the rear. In this were set rubberrings sealing 12 discs of Plexiglas, with bevelled edges so that internal pressure sealed them more tightly on their frames. Pilots said the view was unacceptably poor, as they had done with the original BOK-1. The installation in the second aircraft, with normal unspatted wheels, was a vast improvement. Overall pilot view was hardly worse than from an enclosed unpressurized cockpit (but of course it could not compare with the original open cockpit). The main design problem was the heavily framed windscreen, with an optically flat circular window on the left and the SR optical sight sealed into the thick window in the centre. The main hood was entirely transparent and hinged upwards. Behind, the decking of the rear fuselage was also transparent. The I-153V had a different arrangement: the main hood could be unsealed and then rotated back about a pivot on each side to lie inside the fixed rear transparent deck.

Top left: I-15 with the first GK (canopy with portholes hinged open).

Above right: I-153V.

Left: I-153V cockpit.

Unknown in the outside world, by 1940 Shcherbakov was the world's leading designer of pressurized fighter cockpits.

Polikarpov I 152 DM 2 and M53/DM-4

Purpose: To test ramjet engines and investigate performance of aircraft thus boosted.

Design Bureau: Joint effort by A Ya Shcherbakov (aircraft) and Igor A Merkulov (ramjet engines).

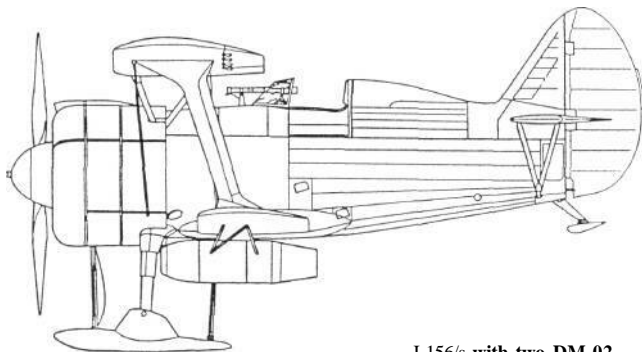
In July 1939 Merkulov proposed that simple subsonic ramjets (PVRD) should be hung under the wings of fighters to boost their performance. Given the go-ahead by Narkomavprom, he collaborated with Shcherbakov in thus boosting Polikarpov biplane fighters. Bench testing the small DM-1 (Dvigatel' Merkulov) engine began in August 1939, and the larger DM-2 (or DM-02) began bench testing a month later. In December 1939 two DM-2 engines were attached under the lower wings of I-152 (I-156/s) No 5942, then ski-equipped, at the M V Frunze Moscow Central Aerodrome. Towards the end of the month pilot Piotr Loginov began flight testing without operating the ramjets. In late December Loginov tested the fuel and ignition systems, and on 27th January 1941 official NII-WS trials

began with the ramjets firing. This was the first flight in the world of any ramjet-equipped manned aircraft. The DM-2 testing involved 54 flights by late June 1940, 34 by Loginov, 18 by A V Davydov and two by N A Sopotsko. By this time Merkulov had extensively tested the considerably larger DM-4. On 3rd September 1940 Loginov first flew an I-153 (No 6034) fitted with two DM-2 ramjets, and on 3rd October he made the first flight of this aircraft with two DM-4s. The DM-4 was also flown under the I-152. Use of the two biplanes as DM test-beds was abandoned in December 1940 after 20 flights with DM-4s.

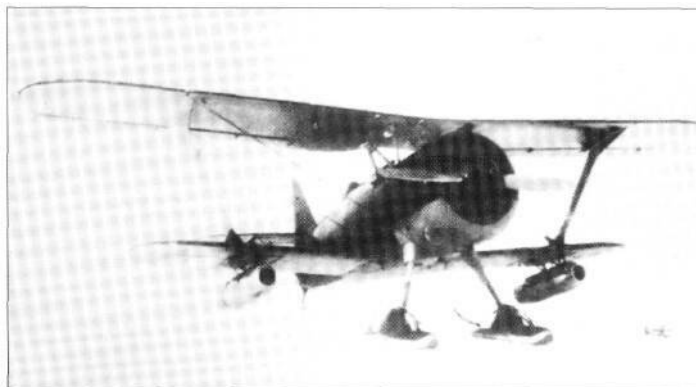
The Merkulov ramjets were simple profiled propulsive ducts burning the same petrol (gasoline) fuel as the aircraft main engine. This was fed by an engine-driven auxiliary pump around the double-skinned jetpipe throat and nozzle to cool the inner wall. Still liquid, the fuel was then sprayed into the interior duct where to initiate combustion it was ignited electrically. The static-tested DM-1 had a diameter of 240mm (9 1/2 in). The DM-2, flown on the I-152, had a diameter of

400mm (1 ft 3 3/8 in), length of 1.5m (4 ft 11 in) and weight of 19kg (41.9 lb). The fabric covering over the I-152 rear fuselage and tail was replaced by thin aluminium, flush-riveted. This proved to be a wise precaution, because with the ramjets operating the flame extended beyond the tail of the aircraft. The DM-4 had a diameter of 500mm (1 ft 7 7/8 in), length of 1.98m (78 in) and weight of 30kg (66 lb).

The ramjets were never fired in the air for as long as a minute, though on bench test five hours was once demonstrated. Most tests were in bursts of about ten seconds, and Loginov recorded the simplicity of control and smoothness of ramjet operation. The two DM-2 ramjets boosted the maximum speed of the I-152 by a maximum of 20km/h (12.4mph), but at the cost of much poorer performance and manoeuvrability with the ramjets inoperative. The DM-4 ramjets boosted the speed of the I-153 by a maximum of 51km/h (31.7mph), from 389 to 440km/h (241.7 to 273.4mph) but again with severe penalties and with excessive fuel consumption.



I-156/s with two DM-02.

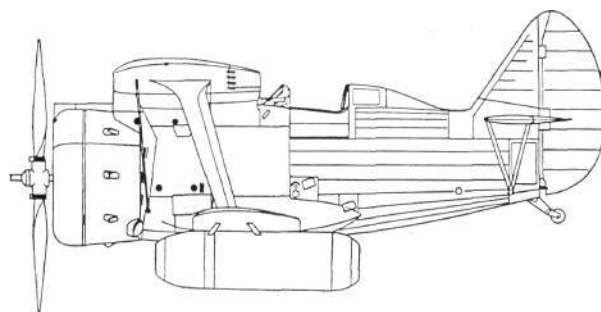
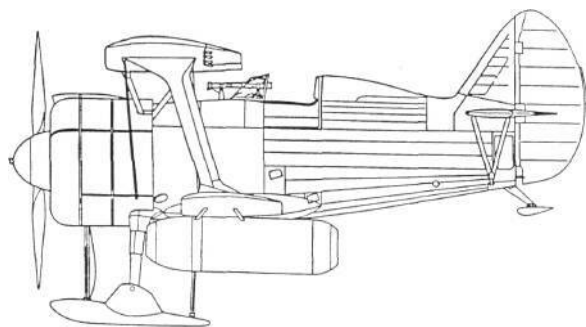


Above: I-156/s with DM-02.



Left: I-153 with DM-02.

M52 with DM-4



I-153 with DM-4



I-153 with DM 4.

Polikarpov Malyutka

Purpose: Short-range interceptor to defend high-value targets.

Design Bureau: OKB of Nikolai N Polikarpov, evacuated to Novosibirsk.

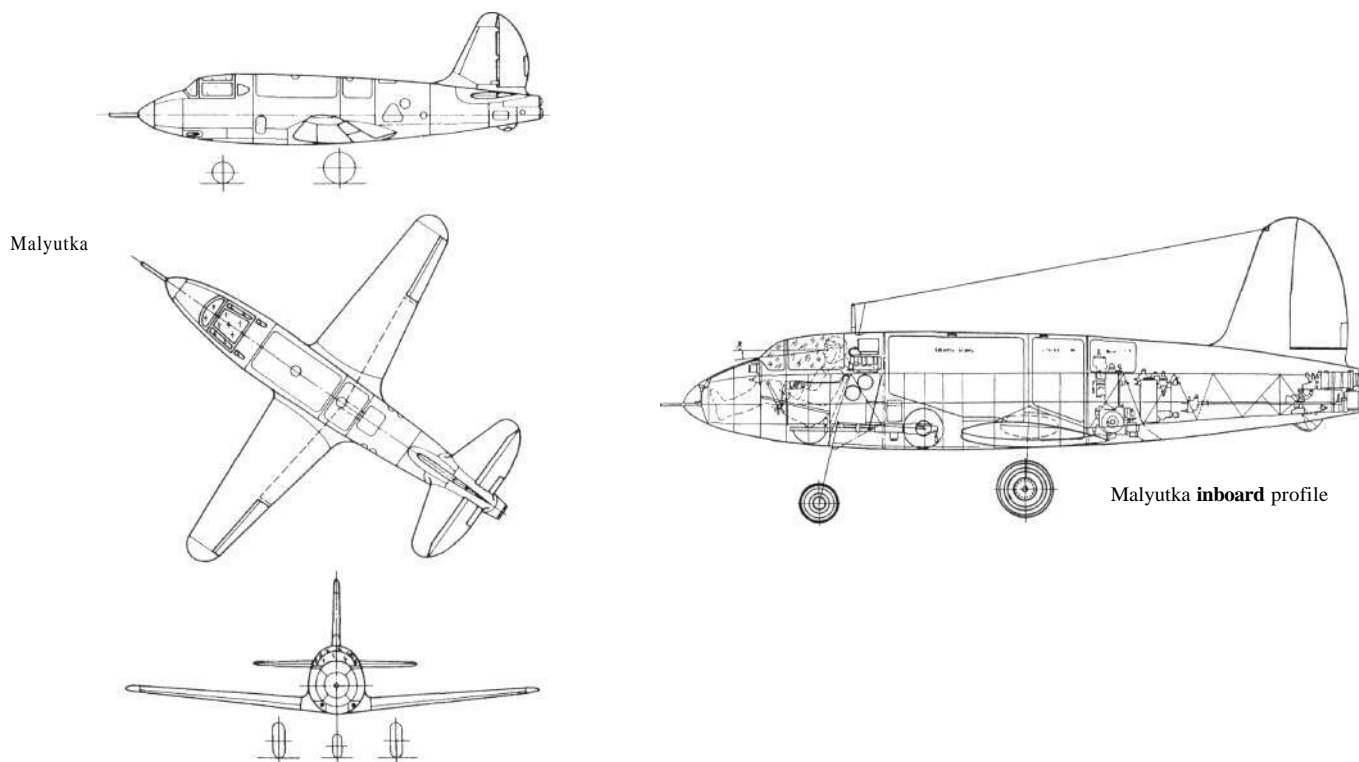
This was the last aircraft of Polikarpov design, and he oversaw its progress himself. It was an OKB project, begun in June 1943. Construction of a single prototype began in early 1944. Progress was rapid until 30th July 1944, when Polikarpov suffered a massive heart attack and died at his desk. Even though the prototype was almost complete, work stopped and was never resumed.

The key to the Malyutka ('Little one') was the existence of the NII-1 rocket engine. Developed by the team led by V P Glushko, this controllable engine had a single thrust chamber fed with RFNA (concentrated nitric acid) and kerosene. Maximum thrust at sea level was 1,200kg, but in this aircraft the brochure figure was 1,000kg (2,205 lb). Bearing no direct

relevance to any previous Polikarpov fighter, the airframe had a curvaceous Shpon (plastic-bonded birch laminates) fuselage sitting on a wing of D-1 stressed-skin construction. The tail was also D-1 alloy. The pressurized cockpit was in the nose, behind which was the radio, oxygen bottles and gun magazines, followed by a relatively enormous tank of acid and a smaller one of kerosene. The tri-cycle landing gears and split flaps were operated pneumatically, and the armament comprised two powerful VYa-23 cannons.

Had it run a year or two earlier this might have been a useful aircraft, though it offered little that was not already being done by the BI and Type 302. At the same time, the death of the General Constructor should not have brought everything to a halt.

| Dimensions (performance estimated) | | |
|------------------------------------|-------------------|-------------------|
| Span | 7.5m | 24 ft 7 in |
| Length | 7.3m | 23 ft 11 in |
| Wing area | 8.0m ² | 86ft ² |
| Weights | | |
| Empty | 1,016kg | 2,240 lb |
| Propellants | 1,500kg | 3,307 lb |
| Loaded | 2,795kg | 6,162 lb |
| Performance | | |
| Max speed at sea level | 890 km/h | 553 mph |
| Time to climb to 5 km | 1 min | 16,404ft |
| Service ceiling | 16km | 52,500 ft |
| Landing speed (empty tanks) | 135 km/h | 84 mph |



Rafaelyants Turbolyot

Purpose: To evaluate a wingless jet VTOL aircraft.

Design Bureau: Aram Nazarovich Rafaelyants, chief engineer of GVF (civil air fleet) repair and modification shops at Bykovo.

Rafaelyants was working at Bykovo, on the Volga, in 1929-59. He had previously produced two lightplanes, flying his RAF-2 to Berlin in 1927. In 1941 his RAF-1 *Ibis* transport nearly went into production. He worked on many aircraft, and after 1945 handled projects concerned with jet engines and their testing. The Rolls-Royce Thrust Measuring Rig ('Flying Bedstead') of 1953 inspired him to produce the Turbolyot. This was flown tethered to a gantry in early 1957, and was publicly demonstrated in free flight in October of that year. Nearly all the flying was done by helicopter test pilot Yu A Garnayev. Because of its historical interest, the Turbolyot is today stored in the WS museum at Monino, although it was not a WS aircraft but a civilian flying test rig.

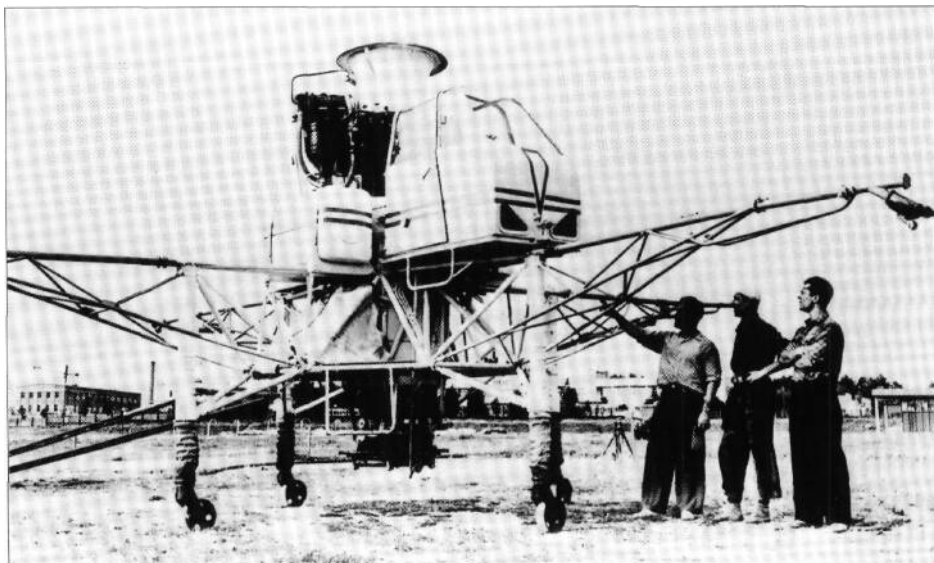
The engine selected was the Lyul'ka AL-9G, a single-shaft turbojet rated at 6,500kg (14,330 lb). This was mounted vertically in the centre of a cruciform framework of welded steel tube. The engine had special bearings

and lubrication, and was fitted with a high-capacity bleed collector ring. On each side was a fuel tank, with fuel drawn equally from both. In front was the enclosed pilot cab, with a door on the right. The bleed system served four pipes, one to each extremity of the vehicle, where downward- and upward-pointing nozzles were provided with a modulating valve under the management of the pilot's control column. The same system also oper-

ated rods and levers governing a two-axis tilting deflector ring under the engine nozzle. Each of the four main structural girders was provided with a long-stroke vertical landing leg with a castoring wheel.

This device never crashed, and provided a solid background of data for the Yak-36 and subsequent jet-lift aircraft.

Turbolyot



Sukhoi Su-5, I-107

Purpose: To create an interceptor with piston engine plus VRDK propulsion.

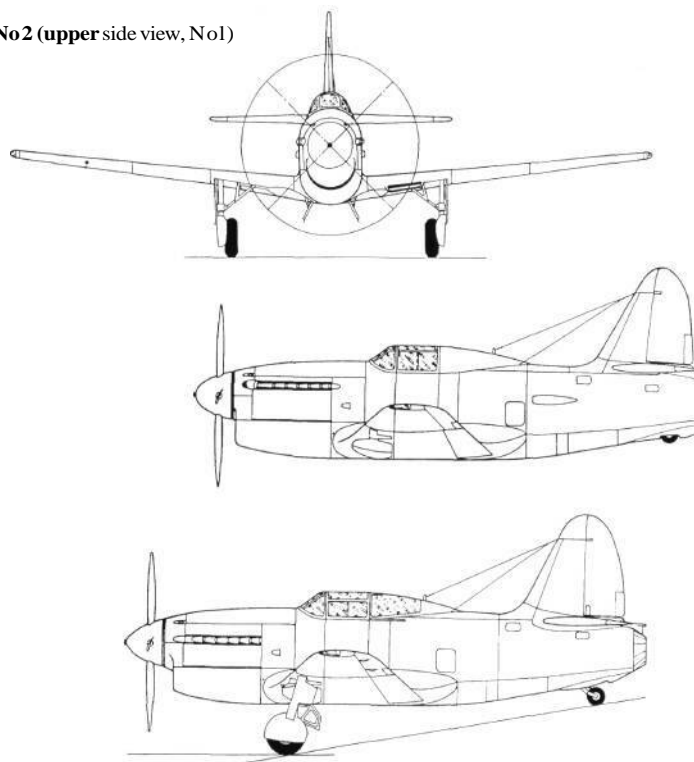
Design Bureau: P O Sukhoi, Moscow.

The urgent demand for faster fighters, to meet the competition of German and Allied jets revealed in January 1944, is given in the story of the Mikoyan I-250 (N). Apart from Mikoyan Sukhoi was the only designer to respond to this call, and (because the propulsion system was the same) he created a very similar aircraft. Two examples were funded, the second being used for tunnel testing at CAHI (TsAGI). The red-painted flight article first flew - it is believed, at Novosibirsk - on 6th April 1945, a month after its rival. On 15th July 1945 the test programme was interrupted by failure of the main engine, and the opportunity was taken to fit a new wing with CAHI (TsAGI) laminar profile. In August the replacement engine failed. As no replacement VK-107A was available, and such aircraft were by this time outmoded, the test programme was discontinued.

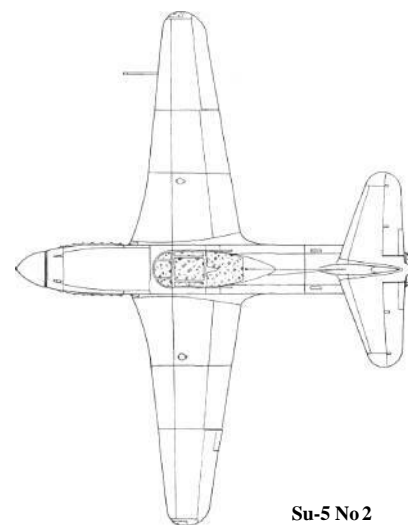
The Su-5 was a conventional fighter of its time, notable only for its small size and deep fuselage to accommodate the VRDK duct. The second wing fitted had a 16.5-per-cent CAHI 1V10 profile at the root, thinned down to 11 per cent NACA-230 near the tip. It was made in three parts, with bolted joints outboard of the landing gears. The split flaps spanned this joint. The Frise ailerons were fully balanced, the port surface having a trim tab. Most of the fuselage was occupied by the propulsion system. The VK-107A engine, rated at 1,650hp, drove a four-blade 2.89m (9ft 5½in) propeller, with a clutched rear drive to a 13:21 step-up gearbox to the VRDK compressor. In the duct were the carburettor inlets, radiator, seven combustion chambers and double-wall pipe of heat-resistant steel leading to a variable propulsive nozzle. The No 2 aircraft had a circular multi-flap nozzle projecting behind the fuselage. In the left inner wing was a broad but shallow inlet for the ducted oil cooler, with exit under the wing. This required a modified upper door to the left landing gear, with 650 x 200 tyres and track of 3.15m (10ft 4in). The tail-wheel, with 300x125 tyre, retracted into an open asbestos-lined box in a ventral fairing. The rudder and inset-hinge elevators all had spring-tab drives. The cockpit had 10mm (¾in) back armour and a sliding canopy, the No 2 aircraft having a transparent rear fairing. Three tanks housed 646 litres (142 Imperial gallons) of fuel, consumed in 10min of VRDK operation. Armament comprised one NS-23 with 100 rounds and two UBS with 400 rounds above the engine.

Sukhoi said later this aircraft was a 'non-starter' from the outset.

Su-5 No 2 (upper side view, No 1)



| Dimensions | | |
|---------------------------------|----------|-------------|
| Span | 10.562m | 34 ft 1½ in |
| Length (No 1) | 8.26m | 26 ft min |
| (No 2) | 8.51m | 27 ft 11 in |
| Wing area | 17.0m² | 183ft² |
| Weights | | |
| Empty | 2,954kg | 6,512 lb |
| Loaded | 3,804 kg | 8,386 lb |
| Performance | | |
| Max speed at sea level | 645 km/h | 401 mph |
| at 7.8 km (25,590 ft) rising to | 810 km/h | 503 mph |
| Time to climb to 5 km | 5.7 min | 16,400ft |
| Service ceiling | 12.05km | 39,535ft |
| Range | 600km | 373 miles |
| Take-off | 345m | 1,358ft |
| Landing speed/ | 140 km/h | 87 mph |
| run | 600m | 1,969ft |



Su-5 No 2

Below: Su-5 No 2.



Sukhoi Su-7R

Purpose: To create a mixed-power (piston engine plus rocket) fighter.

Design Bureau: OKB of Pavel Osipovich Sukhoi, Moscow. Note: this aircraft was not related to the later Su-7 jet fighter.

Having in 1941 seen the Su-2 attack bomber accepted into production, Sukhoi subsequently never dislodged the IL-2/IL-10, despite the excellence of different versions of

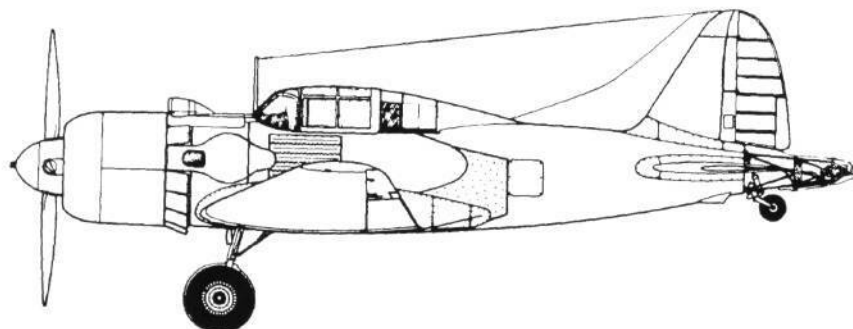
Aircraft A (Su-6). In 1942 he was authorized to develop the A into a single-seat fighter. This flew in late 1943 and underwent various modifications, in its final form being tested by G Komarov between 31st January and 20th December 1945. By this time it was no longer of interest.

The Su-7R was based upon the airframe of the Su-6(A), but with a new all-metal semi-monocoque fuselage. The two-seat cockpit

was replaced by a single-seat cockpit with a unged canopy with a fairing behind it. An additional fuel tank replaced the internal weapons bay, and the large-calibre wing guns were removed, the armament being three synchronized ShVAK 20mm cannon each with 370 rounds. At first the ASh-71 type engine was retained, but this was soon replaced by a smaller and less-powerful ASh-82FN, rated at 1,850hp on 100-octane fuel driving an AV-9L four-blade propeller. In 1944 a TK-3 turbosupercharger was added on each side, and an RD-1KhZ rocket engine was installed in a new extended tailcone. As described previously, this Dushkin/Glushko engine had a single thrust chamber burning the same petrol (gasoline) as the piston engine, which ignited hypergolically (instant reaction) when mixed with RFNA (red fuming nitric acid). The acid was housed in an additional tank behind the cockpit, with access through a dorsal hatch. This tank gave a continuous burn time of about four minutes. When rocket power was selected, the propellants were fed at a rate of 1.6kg (3.5 lb) per second, giving a thrust of 300kg (661 lb) at sea level and about 345kg (761 lb) at high altitude.

By 1945 this aircraft was no longer competitive, and the rocket engine never went into production. In any case, during a practice for the first post-war air display in late 1945 the rocket engine exploded, causing a fatal crash.

Su-7R



Dimensions (final standard)

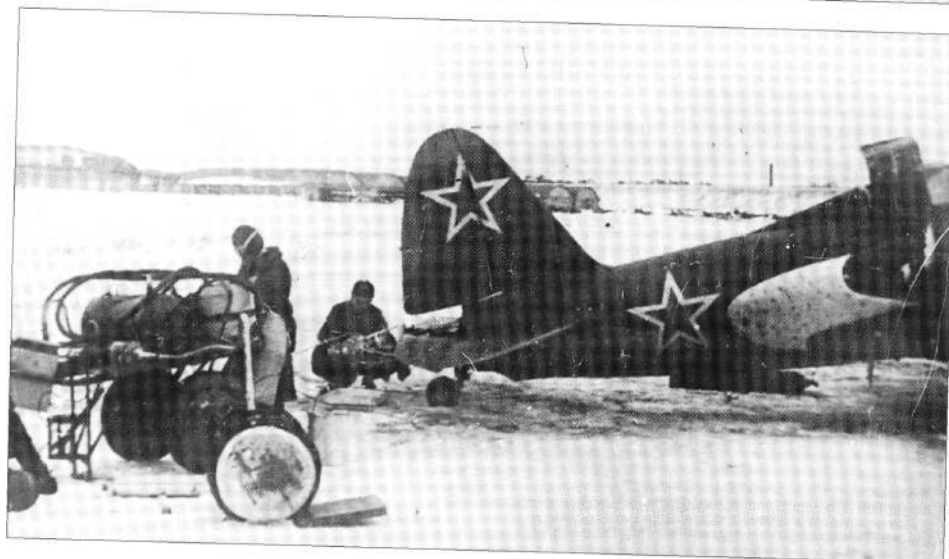
| | | |
|-----------|--------------------|---|
| Span | 13.5m | 44 ft 3 ¹ / ₂ in |
| Length | 10.03m | 32 ft 10 ³ / ₄ in |
| Wing area | 26.0m ² | 280 ft ² |

Weights

| | | |
|---------------|---------------|-----------------|
| Empty | 3,250kg | 7,165lb |
| Fuel/oil/acid | 480/50/180 kg | 1,058/110/397lb |
| Loaded | 4,360kg | 9,612 lb |

Performance

| | | |
|-----------------------------------|----------|-----------|
| Maximum speed | | |
| at sea level (no rocket) | 480 km/h | 298 mph |
| at 7.5 km (24,600 ft) with rocket | 680 km/h | 423 mph |
| at 12 km (39,370 ft) with rocket | 705 km/h | 438 mph |
| Service ceiling | 12,750m | 41,831 ft |
| Range (with full rocket bum) | 800 km | 497 miles |
| Take-off | 300m | 984ft |
| Landing speed/ | 125 km/h | 78 mph |
| run | 350m | 1,148ft |



Left: Two views of Su-7R.

Sukhoi Su-17, R

Purpose: To exceed Mach 1 and possibly serve as the basis for a fighter.

Design Bureau: P O Sukhoi, Moscow.

Note: this aircraft was not related to later aircraft with the same designation.

In late 1947 the Council of Ministers issued a plan for 1948-49 calling for the construction of new experimental aircraft. One type was to research high-subsonic, transonic and low supersonic speeds, and also if possible provide the basis for the design of a supersonic tactical fighter. Contracts were issued to Yakovlev (Type 1000) and Sukhoi (Aircraft R). In each case funds were provided for one flight article and one static test specimen, and Sukhoi's design proceeded rapidly. From the outset provision was made for two heavy cannon, and in 1949 the WS designation Su-17 was issued. As early as July 1949 the flight article was taken to LII-MAP at Zhukovskii, where the assigned pilot, Sergei Anokhin, carried out increasingly fast taxi tests. Just as he was about to make the first flight the Su-15 radar-equipped interceptor suffered violent flutter and crashed, Anokhin ejecting. Rather precipitately, CAHI (TsAGI) blamed Sukhoi, and moreover claimed that the wing of Aircraft R was also torsionally weak and would flutter at high airspeeds. CAHI therefore refused to issue flight clearance for this aircraft. In turn this led Stalin to order that Sukhoi's OKB should be liquidated on 1st November 1949. It was reopened in 1953 after Stalin's death.

This outstanding design was made possible by the rapid development of the powerful TR-3 (later called AL-5) afterburning axial turbojet by A M Lyul'ka, qualified in January 1950 at 4,600kg (10,141 lb), with a dry rating of 4 tonnes (8,818 lb). Had the Su-17 continued it would certainly have later flown with more powerful Lyul'ka engines. The propulsion system was 'straight through' from the plain nose inlet, which immediately divided to pass each side of the cockpit, to the tail. Amid-

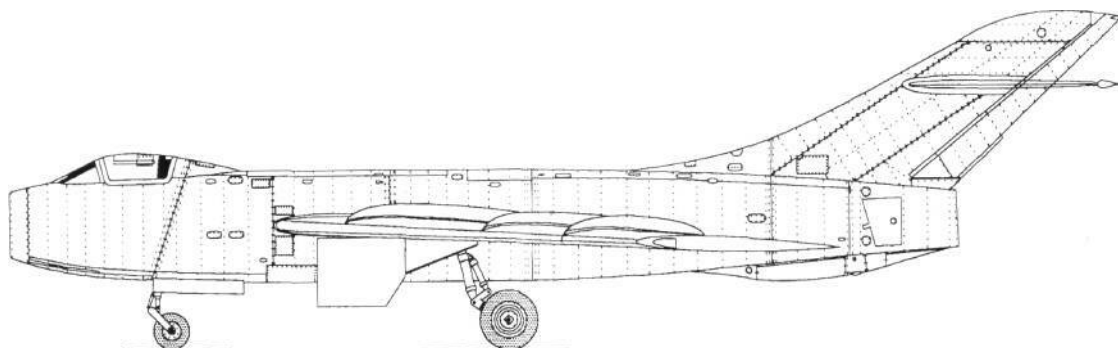
ships, at Frames 15/15A and 20/20A, the main wing spars passed through at mid-level. The wing had CAHI (TsAGI)-9030 profile at the root, changing to symmetric SR-3-12s at the tip, the 1/4-chord sweep being 50°. Above each wing were two full-chord fences plus another from the leading edge to the aileron. Three tracks carried each of the Fowler-type flaps. High on the large vertical tail was mounted the fixed tailplane, again with 50° 1/2-chord sweep and ground adjustable over the range $\pm 1.5^\circ$. The port aileron and starboard elevator had tabs, and the rudder had a section of 'knife' (thin strip behind the trailing edge). This aircraft pioneered Soviet use of hydraulically boosted flight controls, on all axes. All units of the landing gear had levered suspension, using high-pressure shock absorbers pioneered on the Su-15, and retracted into the fuselage. The nose unit had a 530 x 230mm tyre and retracted to the rear, while each main unit had an 800 x 225mm tyre and pneumatic plate brake and retracted forwards about a skewed axis under the wing root, to be covered by a large door. The ventral bulge under the tail had a steel underside and made provision for housing a cruciform braking parachute. On each side of the rear fuselage was a door-type airbrake, opened to 60°, which like the flaps, landing gear and flight controls, was operated by a hydraulic system at what was then a new high pressure of 211kg/cm² (207-MPa, 3,000lb/in²). The cockpit was pressurized, maintaining 0.65kg/cm² (9.2lb/in²) up to 7km (22,966ft) and holding a constant dP of 0.3kg/cm² (4.3lb/in²) above that level. Like several previous Soviet aircraft, the pilot's ejection-seat was mounted in a nose section designed to separate from the fuselage in an emergency. The planar joint, sealed by an inflatable ring, sloped forward to avoid the nose-gear, and it could be broken by firing a cordite charge at the bottom joint, allowing the nose to pivot and separate from the two upper connections. Separation was triggered automatically if vertical accelera-

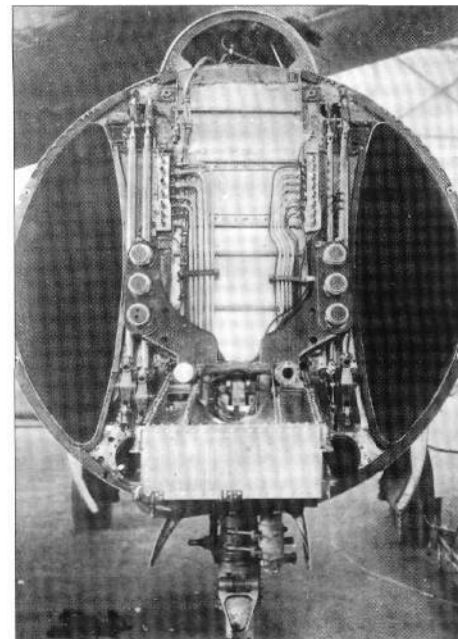
tion reached ± 18 g, or under pilot command. The separated nose streamed a drogue which after a delay extracted the main ribbon parachute. The pilot could then eject, experiencing a maximum of 5 g. The pilot could also eject normally, from the intact aircraft, but only after jettisoning the sideways-hinged canopy. A total of 1,219 litres (268 Imperial gallons) of fuel was housed in the fuselage, there being one metal and two bladder tanks behind the cockpit and three metal tanks (one a toroidal hollow ring) around the jet-pipe. Provision was made for a jettisonable 300 litre (66 Imperial gallon) tank to be scabbled under each wing, and for two N-37 guns, each with 40 rounds, to be mounted in the fuselage. The avionics were comprehensive, including vhf, radio compass, an IFF transponder and precision radio altimeter.

There is no reason to doubt that this aircraft would have been most valuable, and preventing it from flying appears in retrospect to have been a serious error. The Soviet Union suffered from its thoughtless precipitate actions.

| Dimensions | | |
|-------------------------------|--------------------------------|----------------------|
| Span | 9.6m | 31 ft 6 in |
| Length | 15.253m | 50 ft 1/4 in |
| Wing area | 27.5 m ² | 296 ft ² |
| Weights | | |
| Empty | 6,240kg | 13,757 lb |
| Loaded | 7,390kg | 16,292 lb |
| Performance (estimated) | | |
| Max speed, at sea level | 1,252km/h | 778 mph (Mach 1.022) |
| at 10 km (32,808 ft) | 1,152 km/h | 716 mph (Mach 1.08) |
| Time to climb to 10km | 3.5 min | (32,808ft) |
| Service ceiling | 15.5km | 50,853ft |
| Range (internal fuel at 10 km | cruising at 830 km/h, 516 mph) | |
| | 550 km | 342 miles |
| Take-off run | 450m | 1,476ft |
| Landing speed/ | 194 km/h | 120.5 mph |
| run | 660m | 2,165ft |

Su-17, R





Left: Two views of Su-17, R.

Above: Looking back at the Su-17 with jettisonable cockpit removed.

Sukhoi T-3 and PT-7

Purpose: To create a supersonic radar-equipped interceptor.

Design Bureau: Reopened OKB-51 of P O Sukhoi, Moscow.

After closure of his OKB, in December 1949 Sukhoi became deputy to his old colleague A N Tupolev, where among other things he collaborated with CAHI (TsAGI) in establishing the best wing for supersonic fighters. He played the central role in deciding on two contrasting forms. For tactical fighters the choice was an S (Strelovidnoye, arrow like) swept wing with a 14-chord sweep angle of 60° or 62°, and for radar-equipped interceptors the best answer was a T (Treogol'noye, three-angled, ie delta) wing with 14-chord sweep angle of 57° or 60°. For obvious reasons, the latter type of wing was soon dubbed Balalaika. On Stalin's death Sukhoi applied for permission to reopen his OKB. This was at once granted, and in May 1953 he gathered his team at the original premises at 23A Polikarpov Street. Following from his aerodynamic research he received MAP contracts for basically similar aircraft, S-1 with the S wing and T-1 with the T wing. As he chose to build large aircraft powered by a powerful Lyul'ka engine, which matured rapidly, their development was swift. S-1 led to the production Su-7 and many other aircraft. T-1 was replaced on the drawing board by T-3, and

this was flown by V N Makhalin on 26th May 1956. Just over a month later it was the final aircraft in the parade of new fighters at Tushino on 24th June, causing intense interest and great confusion in the West. A few weeks behind came the PT-7. These were tested intensively by a pilot team which included Pronyarkin, Koznov, Kobishkan and the future Sukhoi chief test pilot Vladimir Ilyushin, son of the General Designer.

Like S-1, the T-3 had a barrel-like fuselage, much of its length being occupied by the big afterburning AL-7F engine, rated at 9,000kg (19,840 lb) with afterburner and 6,500kg (14,330 lb) dry. The tails of the two aircraft were almost identical, and there were only minor differences in the cockpit, landing gear and most of the systems. The wings of both aircraft were in the low/mid position, attached by precision bolts to strong forged root ribs on heavy forged fuselage frames. The wing had S-9s profile with a thickness/chord ratio of 4.2 per cent over most of the span. The shape was almost a perfect delta, with a leading-edge angle of 60°. The leading edge was fixed, while the trailing edge comprised rectangular slotted flaps with a maximum angle of 25° and sharply tapered ailerons with inset hinges which extended to the near-pointed tips. Incidence was 0° and dihedral -2° (ie, 2° anhedral). Structurally the wing had three main spars, each principally a machined forg-

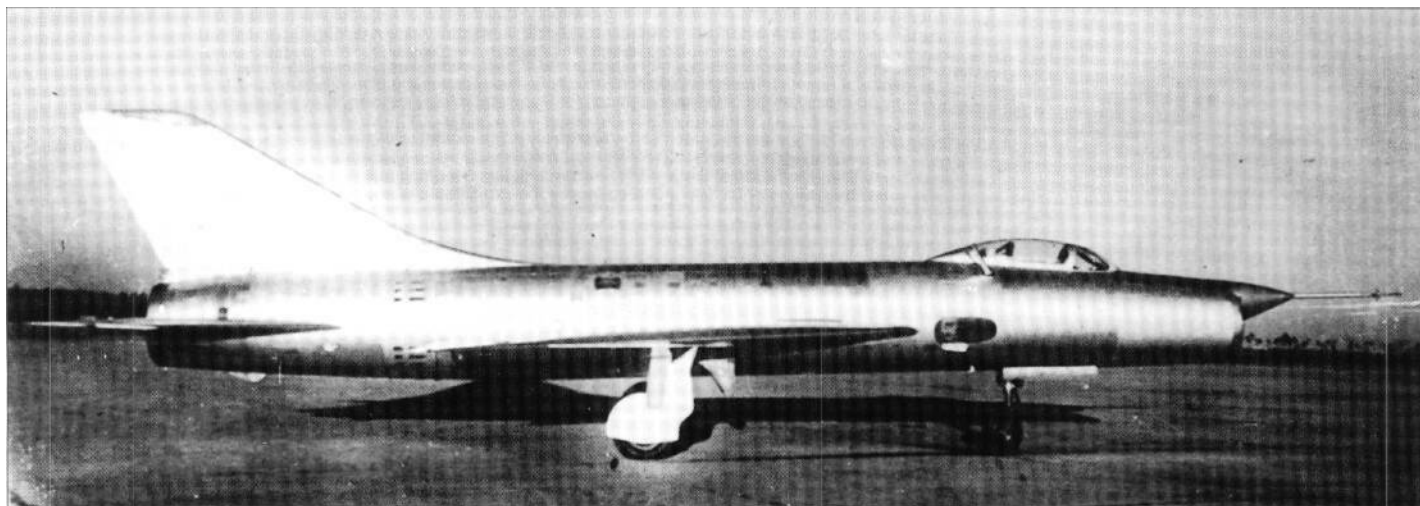
ing, plus a rear spar to carry the trailing-edge surfaces. The leading edge was attached to the front of a further spar forming the front of the structural box. The forward triangle ahead of Spar 1 and the volume between Spars 2 and 3 were sealed and formed integral fuel tanks. The whole space between Spars 1 and 2 was occupied by the retracted main landing gear. The flaps were driven at their inboard ends by electro-hydraulic power units inside fairings under the lower wing surface. The circular-section fuselage was liberally covered with access doors and hatches. The nose was just one of several contrasting answers tested by Sukhoi to the problem of fitting radar into a supersonic fighter. The fire-control system was to be one of the Uragan (Hurricane) family, with the search scanner at the top of the nose and the Almaz (Diamond) ranging radar underneath inside the inlet. The main scanner was inside a low-drag radome in the form of a flattened cone (with a curious upward tilt) from which projected the PVD-7 instrumentation boom combining the pitot/static heads with pitch and yaw vanes. Additional instrument booms were mounted inboard of each wingtip. Even though the T-3 was to be a supersonic aircraft there seemed no alternative to making the radome over the ranging set a bluff hemisphere, which had an adverse effect on pressure recovery in the air inlet. The latter

immediately divided into left and right ducts which quickly expanded into vertically symmetric ducts along each fuselage wall. These combined behind the cockpit into a circular tube passing above the wing and then expanding to fill virtually the entire fuselage cross-section to mate with the face of the engine compressor at Frame 29. Between Frames 31 and 32 on each side of the top of

the fuselage was a large grilled aperture through which hot air could be violently expelled from the compressor during engine start. At Frame 32 a bolted joint enabled the entire rear fuselage to be removed for servicing or changing the engine. At Frame 38 were hinged four door-type airbrakes with large slot perforations. At Frame 43 were the skewed pivots for the horizontal tailplanes, each of which was a single-piece 'slab' with a leading-edge sweep of 60° and an anti-flutter mass projecting forwards near each tip. The large fin curved away from a dorsal extension

in which a screwed panel gave access to the power unit driving the rudder, which was hung on three inset hinges. Each tail surface had chem-milled skins attached to ribs at 90° to the surface rear spar. The fuselage tail end was mainly of titanium. The nose landing gear had a 660 x 200 tyre and retracted forwards. Each main unit had an 880 x 230 tyre and, unlike the swept-wing Sukhoi, retracted straight inwards. Track was 4.65m (15ft 5in) and wheelbase 5.05m (16ft 7in). The cockpit housed an ejection-seat and had a bulletproof windscreen and one-piece

Below: Two views of T-3.



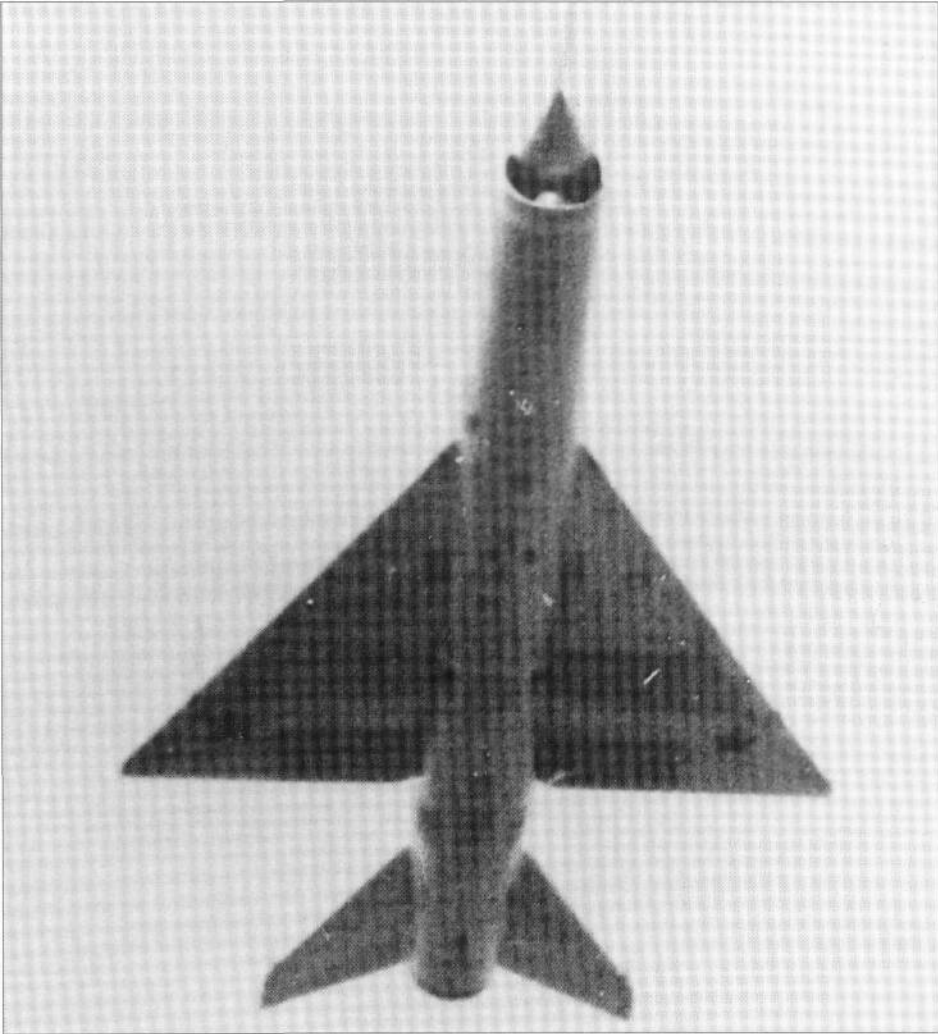
frameless canopy sliding to the rear. Among the comprehensive avionics suite were two items with antennas in the top of the fin, the slots for the Svod (Arch) navaid and SOD-57 transponder and the RSIU-5V inside the dielectric fin cap. The wings were plumbed for drop tanks, to be carried on pylons only just inboard of the instrument booms. The planned armament was two guns (Sukhoi assumed the NR-30), and steel blast panels were pro-

vided in the sides of the forward fuselage. Before the T-3 was completed the guns were replaced by missiles. The intended weapon was the K-6, to be carried on interfaces attached where the tanks would have been.

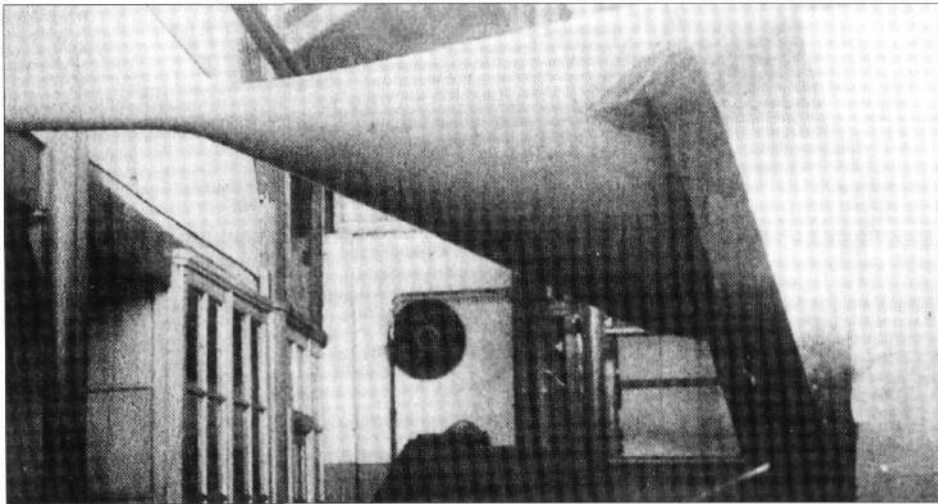
The PT-7 differed mainly in having an area-ruled fuselage, with a visibly waisted middle section, and a new ranging radar with a pointed downward-inclined radome projecting from the bottom of the nose. Other differences

included unperforated airbrakes and a revised fin-cap antenna which extended around the top of the slightly shortened rudder.

These aircraft were the first in what proved to be a long succession of prototype and experimental aircraft in the search for the best interceptor. This underscored the Soviet Union's determination to accept nothing but the best, because any of these aircraft could have been accepted for production.



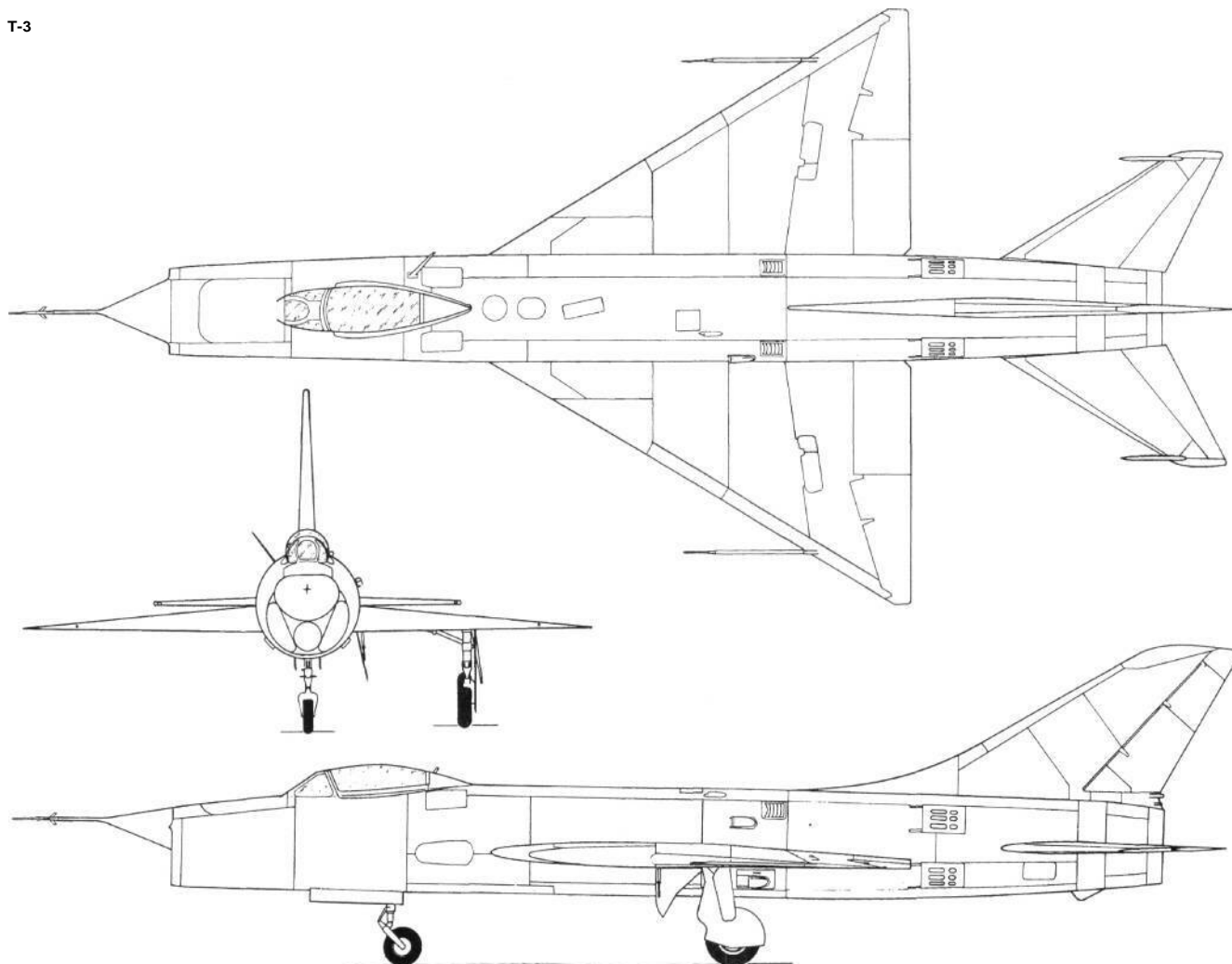
| Dimensions (T-3) | | |
|---------------------------------------|---------------------|-----------------------|
| Span | 8.7 m | 28ft6 1/2 in |
| Length (inc instrument boom) | 18.82 m | 61 ft 8 1/2 in |
| Wing area (net) | 24.9 m ² | 268.8 ft ² |
| Weights | | |
| Empty | 7,490 kg | 16,512 lb |
| Loaded (normal) | 9,060 kg | 19,974 lb |
| Maximum | 11,200 kg | 24,691 lb |
| Performance | | |
| Maximum speed | | |
| at 10 km (32,808 ft) | 2,100 km/h | 1,305 mph (Mach 1.98) |
| Service ceiling | 18 km | 59,055 ft |
| Range (internal fuel) | 1,440 km | 895 miles |
| (maximum) | 1,840 km | 1,143 miles |
| Take-off and landing runs, both about | 1,100 m | 3,600 ft |



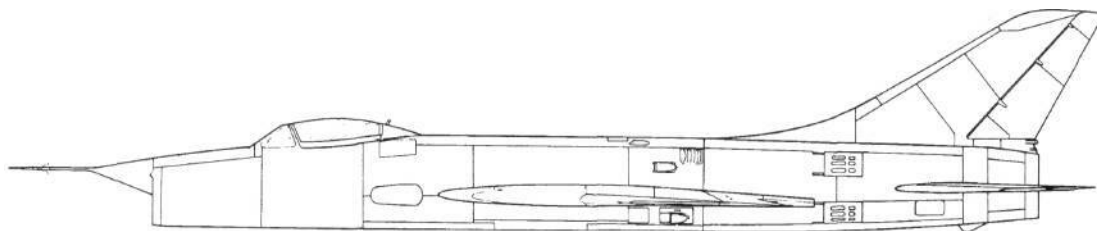
| Dimensions (PT-7) | | |
|---|---------------------|-----------------------|
| Span | 8.7 m | 28ft6 1/2 in |
| Length (inc instrument boom) | 18.82 m | 61 ft 8 1/2 in |
| Wing area (net) | 24.9 m ² | 268.8 ft ² |
| Weights | | |
| In each case approximately 150 kg (331 lb) heavier than the T-3 | | |
| Performance | | |
| Maximum speed | | |
| at 10 km (32,808 ft) | 2,250 km/h | 1,398 mph (Mach 2.12) |

Top: The T-3 at the 1956 Tushino Fly Past.
Bottom: PT-7 inlet.

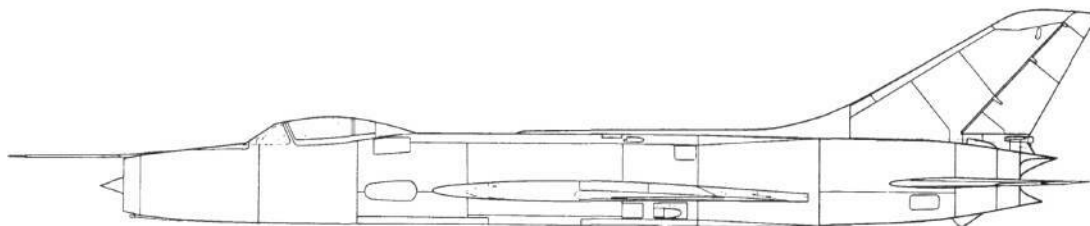
T-3



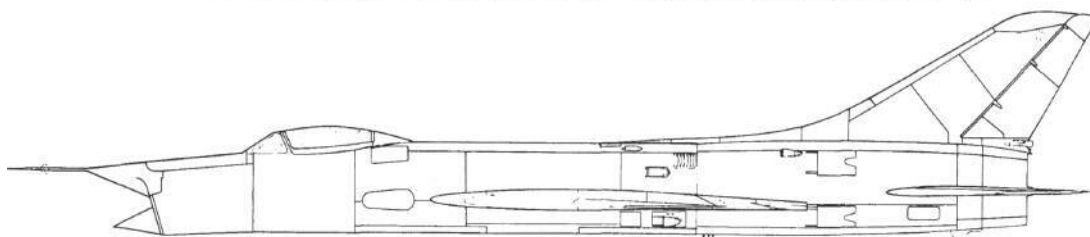
T-3



T-5



PT-7



Sukhoi T-49

Purpose: To create a further-improved interceptor.

Design Bureau: OKB-51 of P O Sukhoi, Moscow.

In May 1958 the OKB-51 decided that, after more than four years of effort, they had still not found the best answer to the problem of how to arrange the radar, air inlet(s) and armament of a single-engined supersonic interceptor. It was recognized that guided missiles would be carried externally, probably under the wings, leaving the nose free for radar, but the engine inlet still posed a problem. The PT-8 and T-47 had large radars centred in a nose inlet, and this was considered to degrade the aerodynamics. Accordingly a new arrangement was devised, and the OKB conveniently were able to graft it on to the incomplete T-39 (T-3 derivative). The result

thus received the designation T-49. By June 1958 work on the T-39 had been stopped, and this project was transferred as a test-bed to the Central Institute of Aviation Motors. Conversion to the T-49 was completed by October 1958. In 1959 M Goncharov was appointed to supervise flight testing, but the T-49 remained on the ground - much of the time being used for various tests - until in January 1960 it was flown by Anatoly Koznov. He reported outstanding acceleration and good all-round performance, but by this time aircraft in this class had been overtaken by later technology. In April 1960 the T-49 was damaged in an inflight accident, and though it was repaired it never flew again.

The T-49 was by virtue of its ancestry very similar to the simpler versions of T-4 family aircraft such as the production Su-9. Like that aircraft it was intended to be armed with two

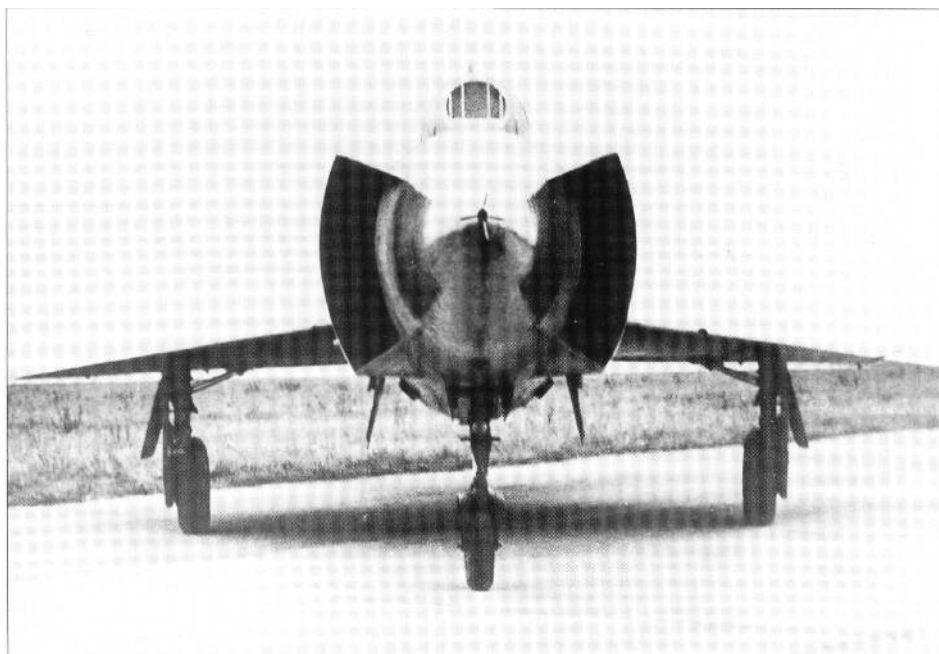
guided missiles carried on pylons under the outer wings, but these would have been of the K-8 type as carried by the Su-11. The large fixed radome was uncompromised by the inlets, which were located well back on each side. In side elevation each inlet was vertical, seen from the front it formed a 90° segment curved round the side of the fuselage, and in plan it was swept back at 60°. To match pressure recovery over the whole range of flight Mach numbers the inner wall was made variable in angle and throat area. The intention was to make the whole inlet system isentropic (causing no change in entropy) to achieve maximum compression of the airflow. Like several other Sukhoi designs of the period there were two vertical doors in each side of the fuselage at Frame 7 to spill excess air from the ducts. The engine was a Lyul'ka AL-7F-100, with a dry rating of 6,900kg (15,212 lb) and maximum afterburning thrust of 9,900kg (21,825 lb). This was achieved without the need for the injection of water, the T-39's rear-fuselage water tank being replaced by one for fuel. Other features included steel doubler plates left over from the T-39 near where gun muzzles would have been had they been fitted, tailplanes fitted with anti-flutter masses and driven over the exceptional angular range +97-16°, and flaps whose trailing-edge roots were cut away at 45°, which was also a feature of the production Su-11.

This promising aircraft was overtaken by galling technology.

Dimensions (Broadly similar to PT-7)

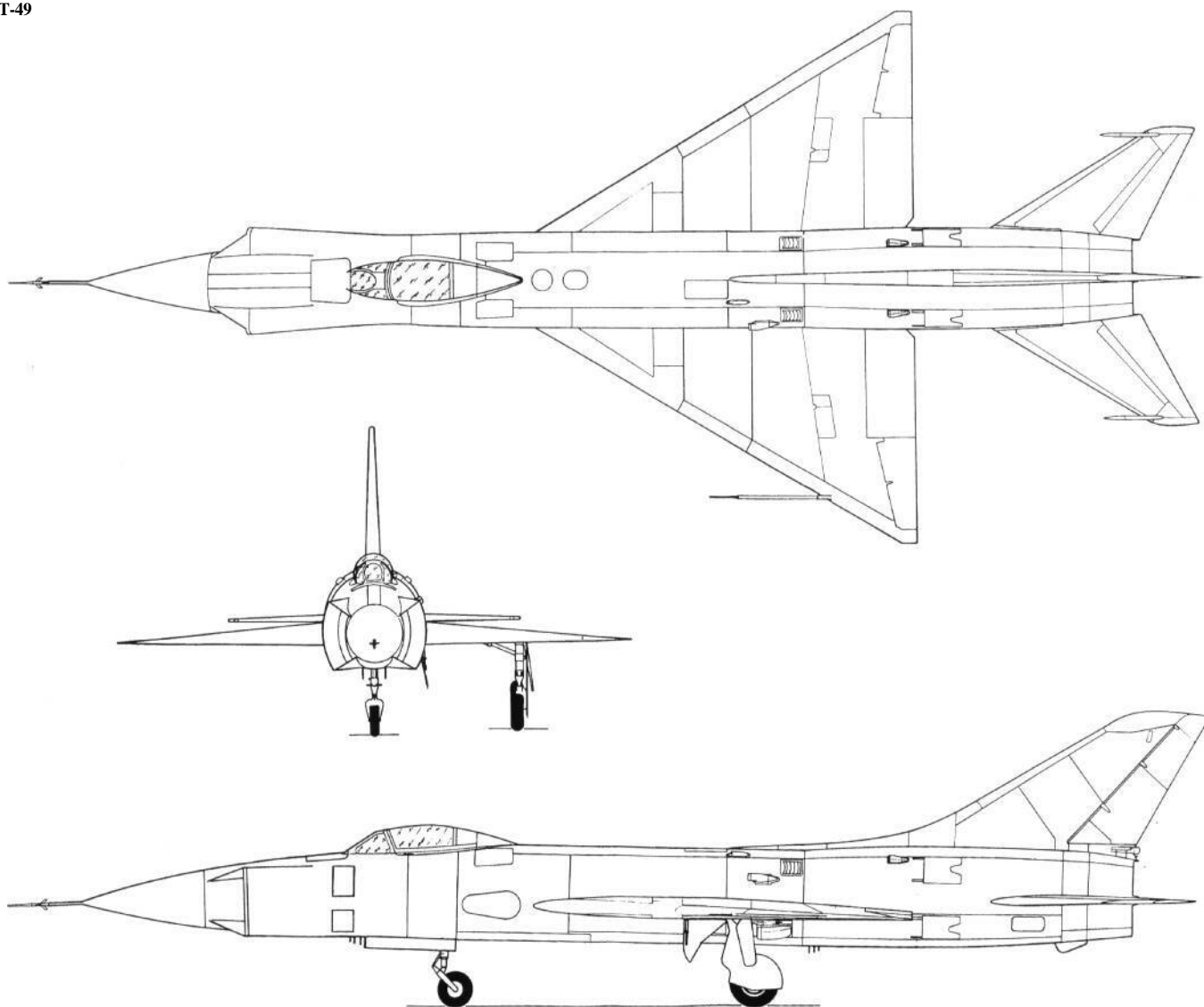
| | | |
|----------------|-------|------------|
| Length | 19.8m | 64 ft m in |
| No other data. | | |

This page and opposite top: Three views of T-49.

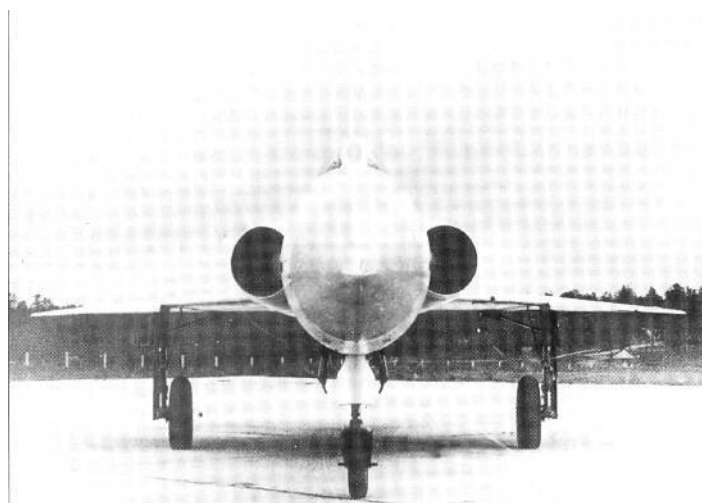




T-49



Sukhoi PI



Purpose: To create a more capable interceptor for the IA-PVO (manned air-defence aviation).

Design Bureau: OKB-51 of P O Sukhoi, Moscow.

In December 1954 the MAP (Ministry of Aviation Industry) requested studies of a new fighter, called P (Perekhvatchik, interceptor). Studies embraced single- and two-seat aircraft armed with every combination of guns, rockets and guided missiles, and with nine types of afterburning turbojet. On 19th January 1955 the Council of Ministers ordered from Sukhoi prototypes of the P-1 powered by a single AL-9 and the P-2 powered by two VK-11 engines. Mockups were reviewed in late 1955, and construction of the P-1 was authorised, the P-2 being abandoned in early 1956. OKB-51's factory constructed the single

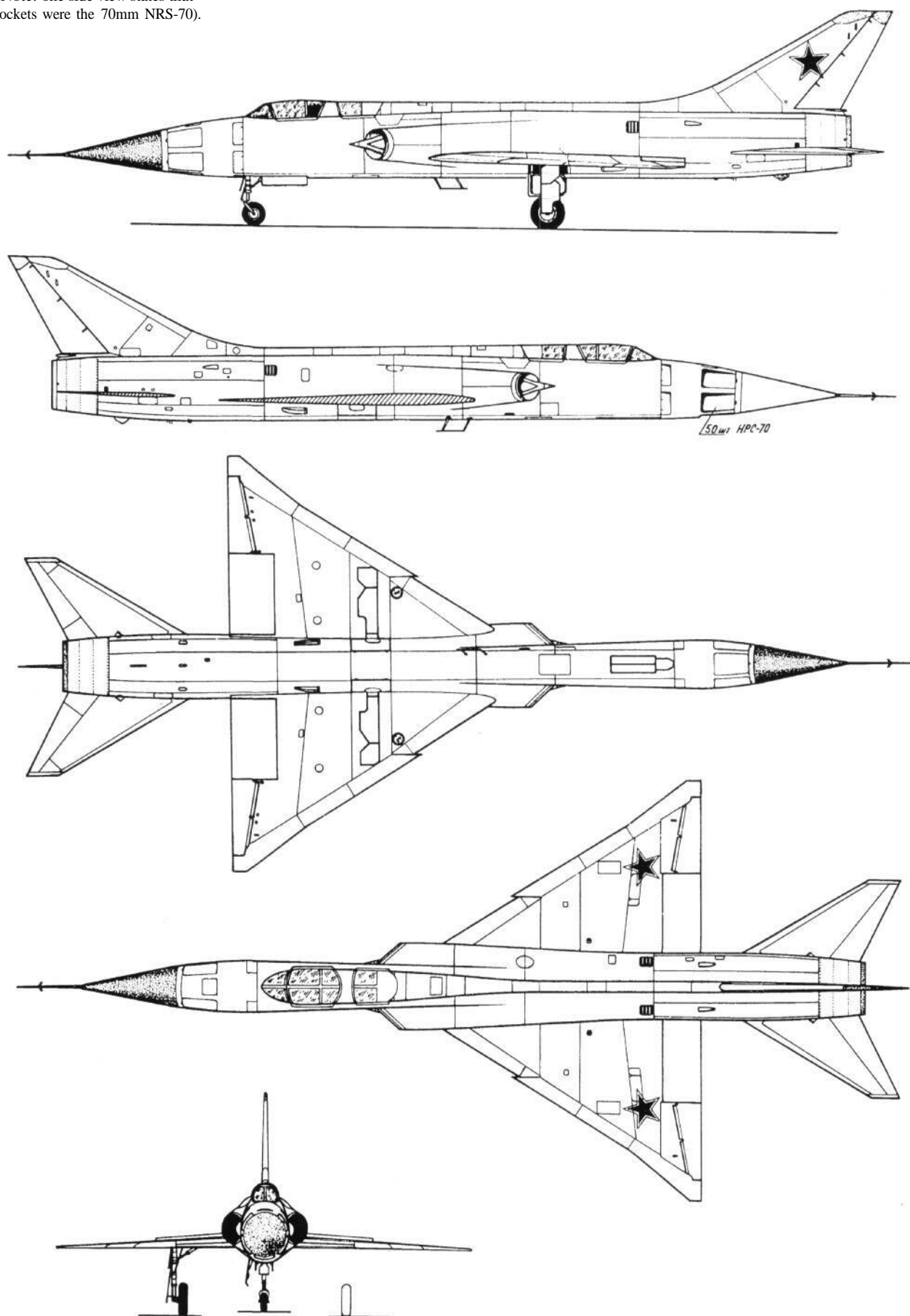
P-1 from August 1956. At a late stage it was recognized that the chosen engine would not be ready in time, and the aircraft was redesigned for an engine of rather less thrust in order to get it airborne. It was taken to the OKB's flight-test station on 10th June 1957, and was flown there by Nikolai Korovushkin on 12th July 1957. He was joined by Eduard Elyan, and Factory Testing was completed on 22nd September 1958. The intended engine never did become available, and Sukhoi failed to obtain an alternative (the R-15B-300 went instead to the T-37). The P-1 was transferred to the experimental category and finally abandoned.

Intended for a more powerful engine, the Lyul'ka AL-9 with an afterburning thrust of 10 tonnes (22,046 lb), the P-1 was thus larger than all the other Sukhoi aircraft of its generation. The wing was scaled up from the earlier

Three views of P-1.

PT-8, which had introduced the feature of a dogtooth discontinuity in the leading edge to create a powerful vortex at large angles of attack to keep flow attached over the upper surface. Unlike the PT-8 the leading-edge sweep was reduced at a point ahead of aileron mid-span from 60° to 55°. Otherwise the wing followed Sukhoi practice with rectangular slotted flaps, sharply tapered ailerons terminating inboard of the tips, landing gears retracting between Spars 1 and 2 and integral tanks ahead of Spar 1 and between Spars 2 and 3. The large fuselage was exceptionally complex. In the nose was the single dish antenna of the Pantera (panther) search and fire-control radar, with the multi-function instrumentation boom projecting from the tip. With this aircraft Sukhoi gave up

P-1 (Note: one side view states that the rockets were the 70mm NRS-70).



trying to put the air inlet in the nose, and the radome formed the entire nose of the aircraft. Next came the bay housing the radar's pressurized container, around which was the main armament. After many changes this comprised five bays, each closed by a rapid-action door, each housing ten ARS-57 57mm spin-stabilized rockets. Upon automatic command by the fire-control system, the rockets were either rippled in rapid sequence or fired in a single salvo, the doors quickly hinging inwards from the front and the rocket gases being discharged through doors at the rear immediately ahead of Frame 8 (the front pressure bulkhead of the cockpit). Next came the nose landing gear, with a K-283 wheel with 570 x 140mm tyre, retracting to the rear, under the floor of the cockpit. The latter was of course pressurized, and accommodated the pilot and radar operator on tandem KS-1 ejection-seats under canopies hinged upwards from the rear. Next came the lateral engine air inlets, which broke new ground in being circular (as they were cut back at a Mach angle of 45° they were actually ellipses), standing slightly away from the fuselage to avoid swallowing boundary-layer air, and housing a half-cone centrebody axially translated to front or rear according to flight Mach number. Downstream the air ducts, and thus the fuselage outer walls, curved sharply inwards to form the common tube feeding the engine. This gave area-rule flow over the wings (an account stating that this aircraft

was not area-ruled is mistaken). Additional non-integral tanks occupied the space between the ducts, with piping in a dorsal spine linking the canopies to the fin (a new feature for Su aircraft). The engine was the well-tried AL-7F, rated at 6,850kg (15,101 lb) dry and 8,950kg (19,731 lb) with afterburner. At double Frames 36/36A the tail could be removed. The tail was similar to that of other Sukhoi prototypes of the era. So were the three hydraulic systems, the two flight-control systems serving a BU-49 power unit for the rudder, a BU-51 driving the one-piece tailplanes (this irreversible drive rendered anti-flutter masses unnecessary) and a BU-52 with rod linkages to the ailerons. The autopilot system used the AP-28 on the tailplanes and AP-39 laterally. The primary hydraulic system also drove the landing gear, the main units having KT-72 wheels with 1,000x 280mm tyres, and the rocket doors, canopies, inlet centrebodies, flaps and (according to documents, though these do not appear on drawings and cannot be seen in photographs) three airbrakes on the rear fuselage. Another puzzle is that one document mentions two NR-30 guns under the nose (one on each side of the bottom rocket compartment, and these are shown in one drawing), while another states that 'in the wing root was an armament section', while two documents state that the main armament comprised two K-7 (replaced by K-8) guided missiles hung on underwing pylons. The lat-

ter would have been outboard, ahead of the ailerons. Another document states that there was provision for an external tank under the fuselage, but this would have been difficult to accommodate because of the landing-gear doors and telemetry antenna. Other avionics included RSIU-4V radio, SPU-2 intercom, Gorizont (horizon) guidance and data link, SRZO-2 IFF, SOD-57M transponder, Sirena-2 (siren) passive warning receiver, ARK-51 ADF, MRP-56P marker receiver, GIK-1 and AGI-1 nav aids, RVU radio altimeter and the RSBN-2 tactical landing guidance.

This complex aircraft never received the intended engine.

| | | |
|------------------------|---------------------|-----------------------|
| Dimensions | | |
| Span | 9.816m | 32 ft 7 in |
| Length | | |
| (incl instrument boom) | 21.83m | 71 ft 7 1/2 in |
| Wing area (gross) | 44m ² | 474ft ² |
| (net) | 28.1 m ² | 302 ft ² |
| Weights | | |
| Empty | 7,710kg | 16,997 lb |
| Loaded (normal) | 10.6 tonnes | 23,369 lb |
| (maximum) | 11,550kg | 25,463 lb |
| Performance | | |
| Maximum speed | | |
| at 15 km (49,213 ft) | 2,050 km/h | 1,274 mph (Mach 1.93) |
| Time to climb to 15km | 2.7 min | (49,213 ft) |
| Service ceiling | 19,500m | 63,976 ft |
| Range (internal fuel) | 1,250km | 777 miles |
| Landing speed | 220 km/h | 137 mph |

Sukhoi T-37

Purpose: To meet an IA-PVO demand for a high-performance automated interception system.
Design Bureau: OKB-51 of P O Sukhoi, Moscow.

In late 1957 the threat of USAF strategic bombers able to cruise at Mach 2 (B-58) and Mach 3 (B-70) demanded a major upgrade in the PVO defence system. At the start of 1958 a requirement was issued for manned interceptors with a speed of 3,000km/h (1,864mph) at heights up to 27km (88,583ft). Mikoyan and Sukhoi responded. Creation of the T-3A-9 interception system was authorised by the Council of Ministers on 4th June 1958. The air vehicle portion of this system was a derivative of the T-3 designated T-3A, and with the OKB-51 factory designation T-37. Detail design of this aircraft took place in the first half of 1959. In February 1960 the single flight article was approaching completion when without warning the GKAT (State Committee for Aviation Equipment) terminated

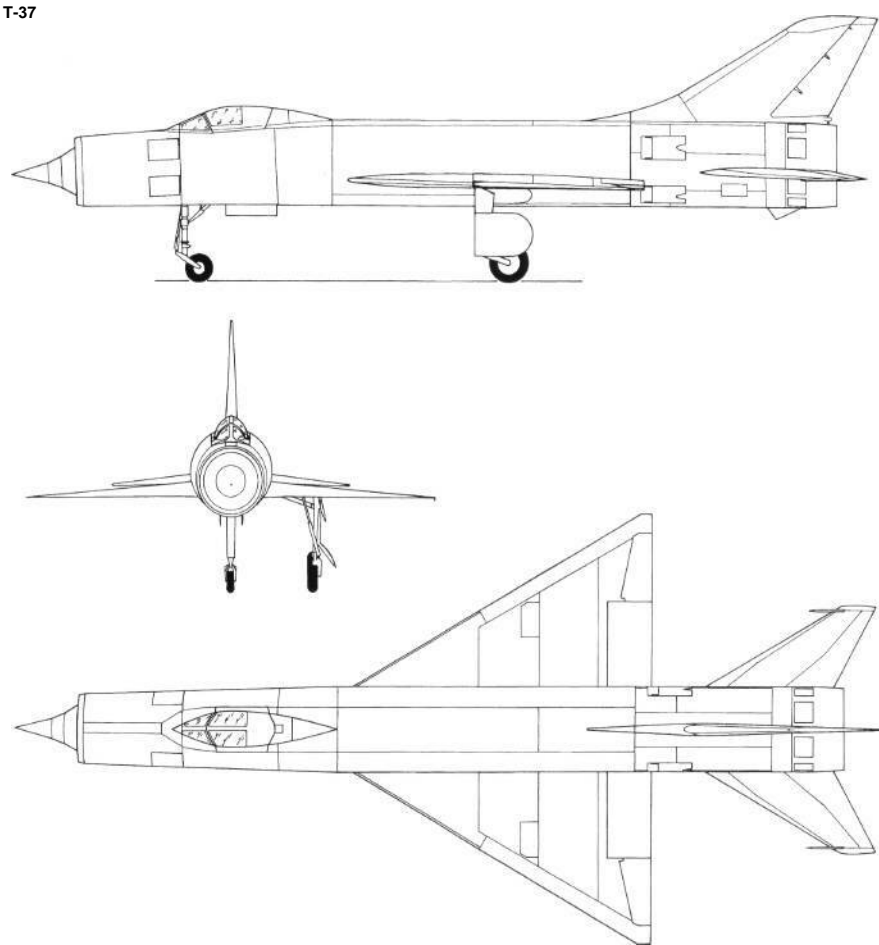
the programme and ordered that the T-37 should be scrapped. The role was temporarily met by the Tu-128 and in full by the MiG-25P.
Though derived from the T-3 the T-37 was an entirely new aircraft which, because of aerodynamic guidance by CAHI (TsAGI) and the use of the same type of engine, had more in common with the MiG Ye-150. The T-3A-9 system comprised this aircraft plus the Looch (ray) ground control system, the ground and airborne radars, a Barometr-2 data link, Kremniy-2M (silicon) NPP (sight) system and two Mikoyan K-9 (R-38) missiles. The aircraft had a wing which was basically a strengthened version of the T-3 wing, with no dog-tooth and with anhedral increased to 3° (ie, -3° dihedral). Each flap could be extended out on two rails to 25° and did not have an inner corner cut off at an angle. A more important change was that to avoid scraping the tail on take-off or landing the main landing gears were lengthened, which meant that the wheels were housed at an oblique angle in

the bottom of the fuselage. The fuselage was totally new, with a ruling diameter of 1.7m (12ft 7in). This was dictated by the Tumanskii R-15-300 afterburning turbojet, with dry and reheat ratings of 6,840kg (15,080 lb) and 10,150kg (22,380 lb) respectively. The TsP-1 radar was housed in a precisely contoured radome whose external profile formed an Os-watitsch centrebody with three cone angles to focus Shockwaves on the sharp inlet lip. The whole centrebody was translated to front and rear on rails carried by upper and lower inlet struts. Surplus air could be spilt through two powered doors in each duct outer wall at Frame 8. The pressurized cockpit had a KS-2 seat and a vee windscreen ahead of a low-drag upward-hinged canopy with a metal-skinned fixed rear fairing. The detachable rear fuselage was made mainly of welded titanium, and terminated in an ejector surrounding the engine's own variable nozzle. Initially a sliding ring, this ejector was changed to an eight-flap design during prototype manufacture. Ram air cooling inlets

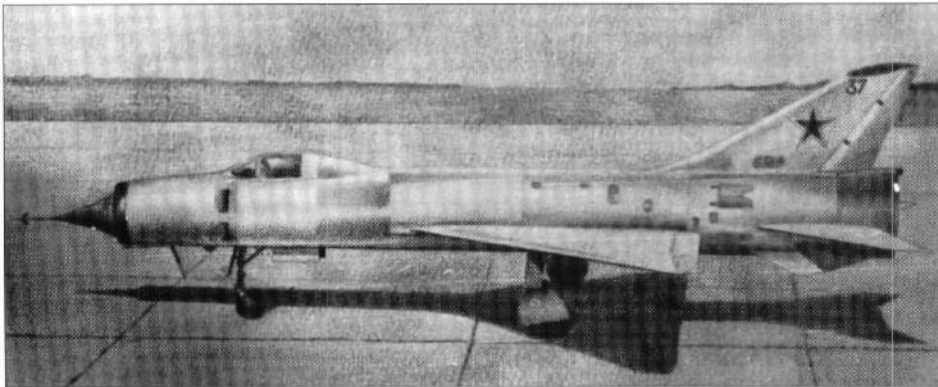
were provided at Frames 25 and 29, and in the detachable rear section were four door-type airbrakes. Under this section were two radial underfins, each incorporating a steel bumper. Pivoted 140mm (5 1/2in) below mid-level the tailplanes had 5° anhedral and did not need anti-flutter rods as they were irreversibly driven over a range of ±2°. Each main landing gear had levered-suspension carrying a plate-braked KT-89 wheel with an 800 x 200mm tyre. The long nose gear had a power-steered lower section with a levered-suspension K-283 wheel with a 570x140mm tyre, and retracted backwards. A total of 4,800 litres (1,056 Imperial gallons) of fuel could be housed in three fuselage tanks (No 3 being of bladder type) and Nos 4 and 5 between wing spars 2 and 3. Provision was made for a 930 litre (204.6 Imperial gallon) drop tank. Missile pylons could be attached ahead of the ailerons. Avionics included the radar, RSIU-5A vhf/uhf with fin-cap antennas, RSBN-2 Svod (arch) navaid and SOD-57M transponder (both with fin slot antennas), Put (course) longer-range navaid, MRP-56P marker receiver, SRZO-2 Khrom-Nikel (chrome-nickel) IFF, Lazur (azure) beam/beacon receiver of the Looch/Vozdukh (rising) ground control system, KSI compass system and a ventral blade antenna for the flight-test telemetry.

Like the rival Mikoyan Ye-150 series (which were produced more quickly) this weapon system was overtaken by later designs.

T-37



| Dimensions | | |
|--------------------------------|----------------------|-----------------------|
| Span | 8.56 m | 28 ft 1 in |
| Length overall | 19.413 m | 63 ft 8 in |
| Wing area (gross) | 34 m ² | 366 ft ² |
| (net) | 24.69 m ² | 265.8 ft ² |
| Weights | | |
| Empty | 7,260 kg | 16,005 lb |
| Loaded (normal) | 10,750 kg | 23,699 lb |
| (maximum) | 12 tonnes | 26,455 lb |
| Performance (estimated) | | |
| Max speed at 15 km (49,213 ft) | 3,000 km/h | 1,864 mph (Mach 2.8) |
| Service ceiling | 25-27 km | 82,021-88,583 ft |
| Range | 1,500 km | 932 miles |
| (with external tank) | 2,000 km | 1,243 miles |



Two artist's impressions of a T-37.

Sukhoi T-58VD

Purpose: To provide full-scale STOL jet-lift data to support the T6-1.

Design Bureau: OKB-51 of P O Sukhoi, Moscow.

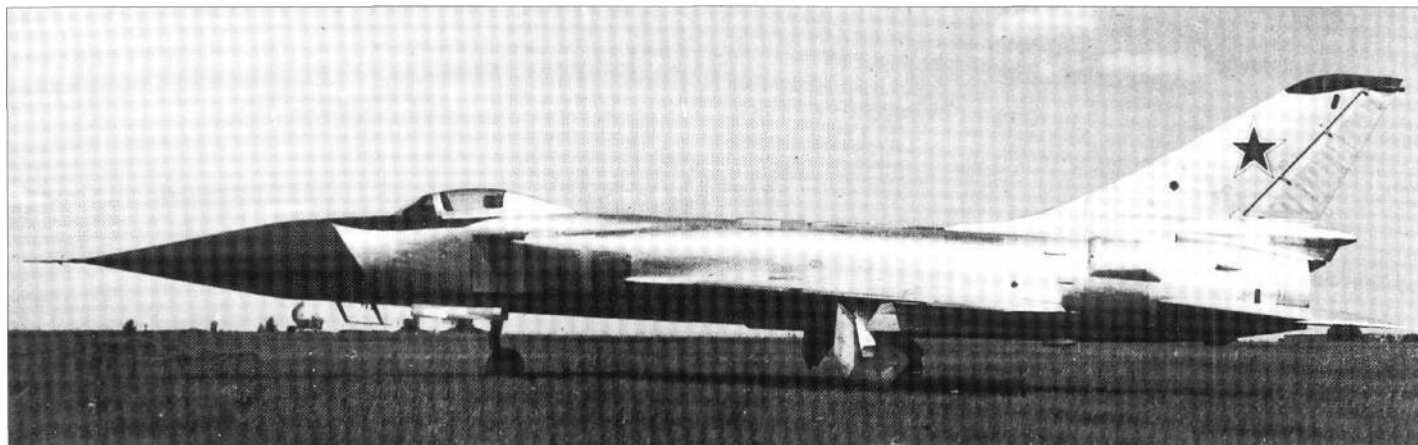
Early history of the T6-1 (see page 178) revolved around how best to create a formidable tactical aircraft with a short field length. One of the obvious known methods of making a STOL (short take-off and landing) aircraft was to fit it with additional jet engines arranged vertically to help lift the aircraft at low speeds. In January 1965 the T-58D-1, the first prototype of what was to become the Su-15 interceptor, was taken off its normal flight programme and returned to an OKB factory. Here it was modified as the T-58VD, the designation meaning *Vertikalnyye Dvigateli*, vertical engines. Managed by R Yarmarkov, who had been leading engineer throughout T-58D testing, ground running trials of the VD began in December 1966. This work required an enormous test installation built at the OKB-51 which used a 15,000hp NK-12 turboprop to blast air at various speeds past the T-58VD while it performed at up to full power on all five engines. It was mounted on a special

platform fitted with straingauges to measure the thrust, drag and apparent weight. When these tests were completed, the T-58VD was taken to the LII at Zhukovskii where it began its flight-test programme on 6th June 1966. Initial testing was handled by Yevgenii Solov'yov, who was later joined by the OKB's Vladimir Ilyushin. On 9th June 1967 this aircraft was flown by Solov'yov at the Domodedovo airshow, where NATO called it 'Flagon-B'. Its basic test programme finished two weeks later. It then briefly tested the ogival (convex curved) radome used on later Su-15 aircraft and the UPAZ inflight-refuelling pod. It was then transferred to the Moscow Aviation Institute where it was used as an educational aid.

The original T-58D-1 was built as an outstanding interceptor for the IA-PVO air-defence force, with Mach 2.1 speed and armament of K-8M (R-98) missiles. Powered by two R-11F2S-300 turbojets (as fitted to the MiG-21 at that time), each with a maximum afterburning rating of 6,175kg (13,613lb), it had pointed delta wings with a leading-edge angle of 60°, fitted with blown flaps. The wings looked very small in comparison with

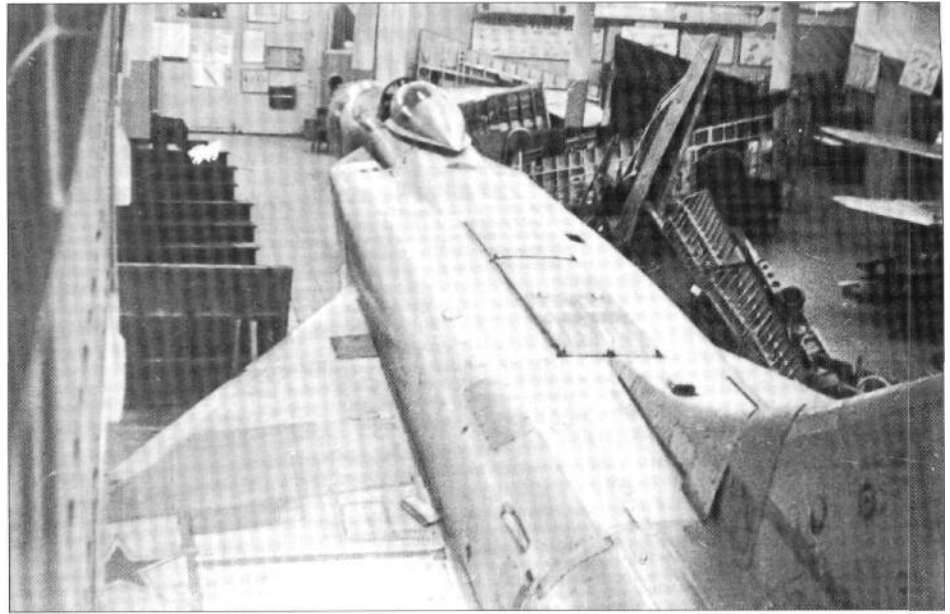
the fuselage, which had backswept rectangular variable-geometry engine inlets on each side. To convert it into the T-58VD a completely new centre fuselage was spliced in. This used portions of the original air ducts to the main engines but separated them by new centreline bays for three lift jets. The front bay housed a single RD-36-35 turbojet of P A Kolesov design with a thrust of 2,300kg (5,180lb). One of the wing main-spar bulkheads came next, behind which was a bay housing two more RD-36-35 engines in tandem. Each bay was fireproof and fitted with all the support systems shown to be needed in previous jet-lift aircraft. On top were large louvred inlet doors each hinged upward at the rear, while underneath were pilot-controlled cascade vanes for vectoring the lift-jet thrust fore and aft. Another important modification was to redesign the outer wing from just inboard of the fence, reducing the leading-edge sweep to 45° and extending the aileron to terminate just inboard of the new squared-off tip. Apart from the missile pylons

This page and opposite top: Views of T-58VD, one showing its final use at the MAI.

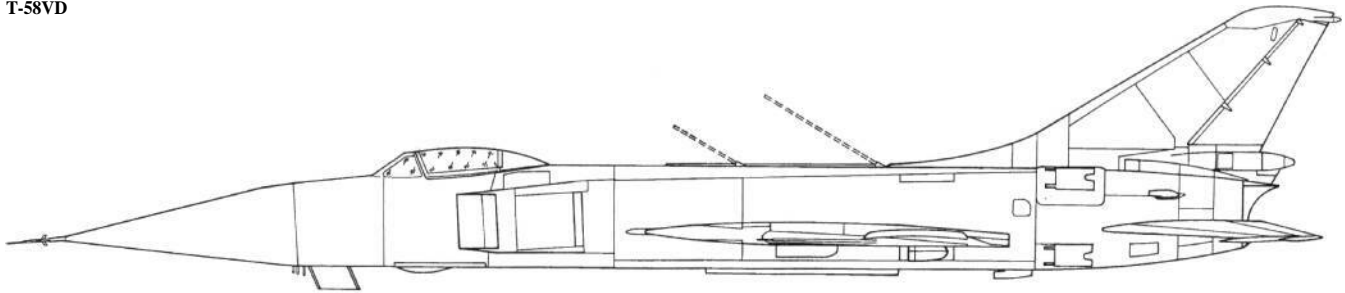


military equipment was removed, and a new telemetry system was fitted with a distinctive twin-blade antenna under the nose.

The jet-lift conversion reduced take-off speed and ground run from 390km/h (242mph) and 1,170m (3,839ft) to a less frantic 290km/h (180mph) and only 500m (1,640ft). Landing speeds and distances were reduced from 315km/h (196mph) and 1,000m (3,281ft) to 240km/h (149mph) and 600m (1,969ft). This was achieved at the expense of reduced internal fuel capacity and sharply increased fuel consumption at take-off and landing. Moreover, it was discovered during initial flight testing that the longitudinal locations of the three lift engines had been miscalculated. Operation of the front RD-36-35 caused a nose-up pitching moment which the pilot could not counteract at speeds below about 320km/h (199mph), so this lift engine could not be used on landings.



T-58VD



Sukhoi S-22I

Purpose: To modify a tactical fighter to have a variable-sweep wing.

Design Bureau: OKB-51 of P O Sukhoi, Moscow.

Spurred by the USAF/USN TFX programme, Sukhoi (and later Mikoyan) researched aircraft with variable sweepback, also called VG, variable-geometry, 'swing wings'. Extensive model testing began at CAHI (TsAGI) in 1963. In early 1965 Sukhoi OKB Deputy N G Zyrin was appointed Chief Designer of the project, with V Krylov team leader. To test full-scale wings the OKB-51 factory selected a production Su-7BM which it had already been using for a year to test other advances. L Moiseyshchikov was appointed chief flight-test engineer. Modification of the aircraft took place in January-July 1966, and Vladimir Ilyushin made the first flight on 2nd August 1966. Later LII pilots evaluated the aircraft, and on 9th July 1967 OKB pilot Evgeny Kuku-shev flew it publicly at the Domodedovo air display. Testing was completed at the end of

1967, and though this was clearly an interim aircraft the Council of Ministers decreed that series production should begin in 1969. Unexpectedly, derived versions remained in production to 1991, over 2,000 being delivered.

It was by no means certain that an existing wing could be modified with variable sweepback. The problem was to minimise weight growth whilst at the same time almost eliminating longitudinal shift in centre of pressure (wing lift) and centre of gravity. The original wing had the considerable leading-edge angle of 63°, matched to the supersonic maximum speed attainable. The intention was to enable the wing to pivot forward, to increase span and lift at low speeds. Doing so would naturally move the centre of pressure forwards, and at the same time it would also move the centre of gravity forwards. The objective was to make these cancel out. This was achieved by pivoting only the outer 4.5m (14ft 9in), placing the pivots close behind the main landing gear in a region well able to diffuse the concentrated loads into the struc-

ture. Each outer panel was driven hydraulically forward to a minimum sweep of 30°. Following tunnel testing of models, three sections of slat were added over almost the whole span of each pivoted leading edge. Inboard of the pivot the existing fence was made deeper and extended under the leading edge to serve as a stores pylon (plumbed for a tank). Among structural changes, the upper and lower skins were each reinforced between the fence and flap by pairs of axial stiffeners (thus, eight in all).

Though empty weight was increased from 8,410kg (18,541 lb) to the figure given below, and internal fuel was reduced by 404 litres (89 Imperial gallons), flying at 30° sweep extended both range and endurance, and enabled much heavier external loads to be lifted from short fields. Pilots reported very favourably on all aspects of handling, except for the fact that at extreme angles of attack there was no stall-warning buffet.



Dimensions

| | | |
|-----------------|---------------------|---------------------------|
| Span (63°) | 10.03m | 32 ft 10 $\frac{1}{2}$ in |
| (30°) | 13.68m | 44ft10 $\frac{3}{4}$ in |
| Length overall | 19.03 m | 62 ft 5 $\frac{1}{4}$ in |
| Wing area (63°) | 34.45m ² | 370.8ft ² |
| (30°) | 38.49m ² | 414.3ft ² |

Weights

| | | |
|--|---------|-----------|
| Empty | 9,480kg | 20,899 lb |
| No further data, but abundant data exists for production successors. | | |

Two views of the S-221.



Sukhoi T-4, 100

Purpose: To create a Mach-3 strategic weapons system.

Design Bureau: P O Sukhoi, Moscow, with major subcontract to TMZ, Tushino Machine-Building Factory.

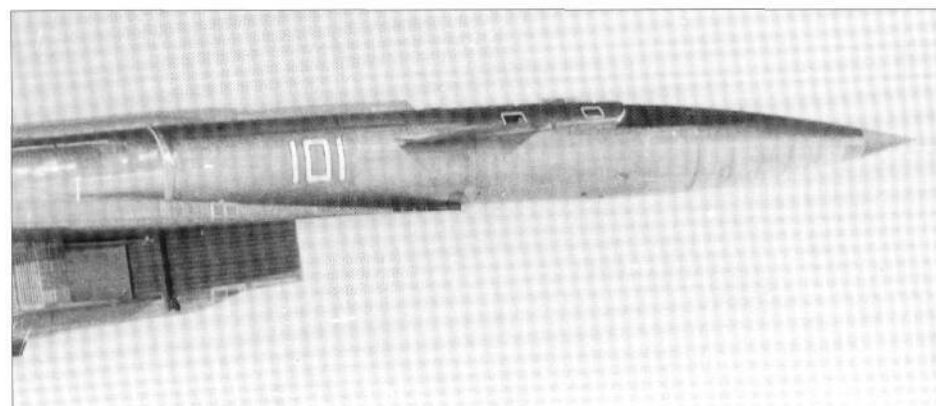
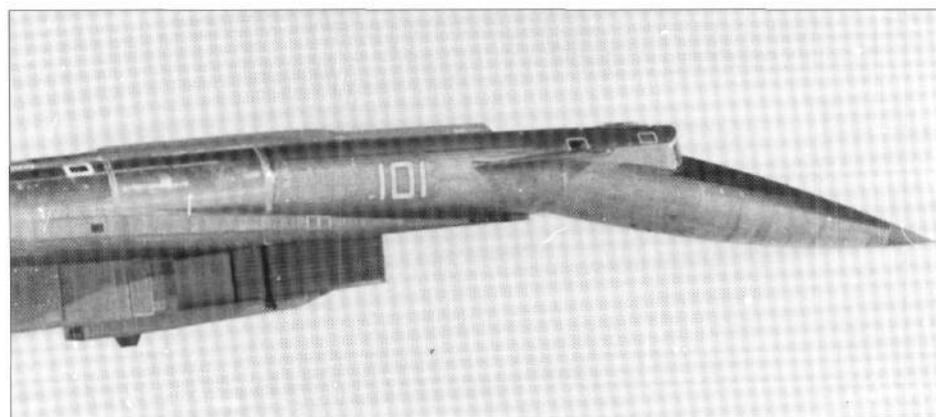
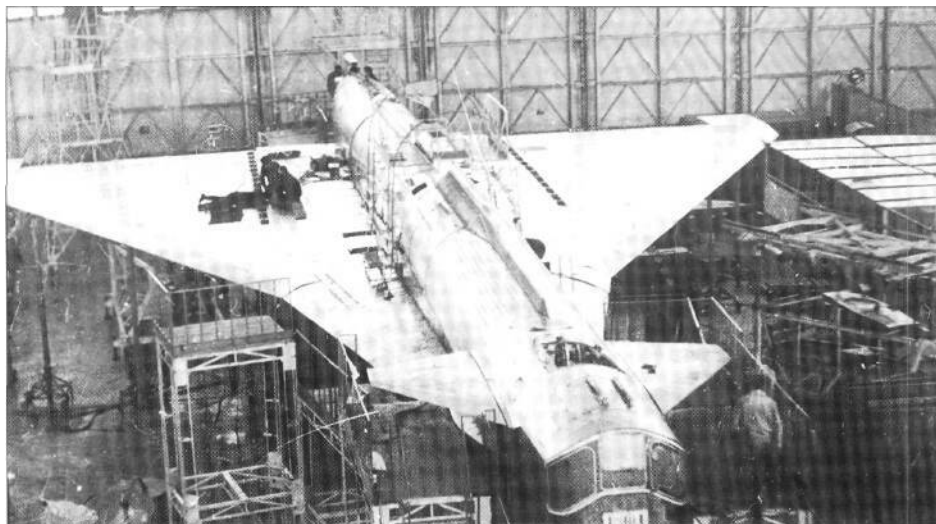
This enormous project was triggered in December 1962 by the need to intercept the B-70 (or RS-70), 'A-11' (A-12, later SR-71), Hound Dog and Blue Steel. At an early stage the mission was changed to strategic reconnaissance and strike for use against major surface targets. It was also suggested that the basic air vehicle could form the starting point for the design of an advanced SST. From the outset there were bitter arguments. Initially these centred on whether the requirement should be met by a Mach-2 aluminium aircraft or whether the design speed should be Mach 3, requiring steel and/or titanium. In January

1963 Mach 3 was selected, together with a design range at high altitude on internal fuel of 6,000km (3,728 miles). General Constructors Sukhoi, Tupolev and Yakovlev competed, with the T-4, Tu-135 and Yak-33 respectively. The Yak was too small (in the TSR.2 class) and did not meet the requirements, and though it looked like the B-70 the Tupolev was an aluminium aircraft designed for Mach 2.35. From the start Sukhoi had gone for Mach 3, and its uncompromising design resulted in its being chosen in April 1963. This was despite the implacable opposition not only of Tupolev but also of Sukhoi's own deputy Yevgenii Ivanov and many of the OKB's department heads, who all thought this demanding project an unwarranted departure from tactical fighters. Over the next 18 months their opposition thwarted a plan for the former Lavochkin OKB and factory to assist the

T-4, and in its place the Boorevestnik (stormy petrel) OKB and the TMZ factory were appointed as Sukhoi branch offices, the Tushino plant handling all prototype construction. A special WS commission studied the project from 23rd May to 3rd June 1963, and a further commission studied the refined design in February-May 1964. By this time the T-4 was the biggest tunnel-test project at CAHI (TsAGI) and by far the largest at the Central Institute of Aviation Motors. The design was studied by GKAT (State aircraft technical committee) from June 1964, and approved by it in October of that year. By this time it had outgrown its four Tumanskii R-15BF-300 or Zubets RD-17-15 engines and was based on four Kolesov RD-36-41 engines. In January 1965 it was decided to instal these all close together as in the B-70, instead of in two pairs. Mockup review took place from 17th January

to 2nd February 1966, with various detachable weapons and avionics pods being offered. Preliminary design was completed in June 1966, and because its take-off weight was expected to be 100 tonnes the Factory designation 100 was chosen, with nickname Sotka (one hundred). The first flight article was designated 101, and the static-test specimen 100S. The planned programme then included the 102 (with a modified structure with more composites and no brittle alloys) for testing the nav/attack system, the 103 and 104 for live bomb and missile tests and determination of the range, the 105 for avionics integration and the 106 for clearance of the whole strike/reconnaissance system. On 30th December 1971 the first article, Black 101, was transferred from Tushino to the LII Zhukovskii test airfield. On 20th April 1972 it was accepted by the flight-test crew, Vladimir Ilyushin and navigator Nikolai Alfeyorov, and made its first flight on 22nd August 1972. The gear was left extended on Flights 1 through 5, after which speed was gradually built up to Mach 1.28 on Flight 9 on 8th August 1973. There were no serious problems, though the aft fuselage tank needed a steel heat shield and there were minor difficulties with the hydraulics. The WS request for 1970-75 included 250 T-4 bombers, for which tooling was being put in place at the world's largest aircraft factory, at Kazan. After much further argument, during which Minister PVDement'yev told Marshal Grechko he could have his enormous MiG-23 order only if the T-4 was abandoned, the programme was cancelled. Black 101 flew once more, on 22nd January 1974, to log a total of 10hrs 20min. Most of the second aircraft, article 102, which had been about to fly, went to the Moscow Aviation Institute, and Nos 103-106 were scrapped. Back in 1967 the Sukhoi OKB had begun working on a totally redesigned and significantly more advanced successor, the T-4MS, or 200. Termination of the T-4 resulted in this even more remarkable project also being abandoned. In 1982 Aircraft 101 went to the Monino museum. The Kazan plant instead produced the Tu-22M and Tu-160.

In all essentials the T-4 was a clone on a smaller scale of the North American B-70. The structure was made of high-strength titanium alloys VT-20, VT-21L and VT-22, stainless steels VIS-2 and VIS-5, structural steel VKS-210 and, for fuel and hydraulic piping, soldered VNS-2 steel. The wing, with 0° anhedral, had an inboard leading-edge angle of 75° 44', changed over most of the span to 60° 17'. Thickness/chord ratio was a remark-



Four views of the T-4 No101

able 2.7 per cent. The leading edge was fixed. The flight controls were driven by irreversible power units in a quadruplex FBW (fly-by-wire) system with full authority but automatic manual reversion following failure of any two channels. They comprised four elevons on each wing, flapped canard foreplanes and a two-part rudder. The fuselage had a circular diameter of 2.0m (6ft 6in). At airspeeds below 700km/h (435mph) the nose could be drooped 12° 12' by a screwjack driven by hydraulic motors to give the pilot a view ahead. Behind the pilot (Ilyushin succeeded in getting the proposed control wheel replaced by a stick) was the navigator and systems manager. Both crew had a K-36 ejection-seat, fired up through the normal entrance hatch, and aircraft 101 also had a pilot periscope. Behind the pressure cabin was a large refrigerated fuselage section devoted to electronics. Next came the three fuel tanks, filled with 57 tonnes (125,661 lb) of specially developed RG-1 naphthyl fuel similar to JP-7. Each tank had a hydraulically driven turbopump, and the fuel system was largely automated. A production T-4 would have had provision for a large drop tank under each wing, and for air refuelling. Behind the aft tank were systems compartments, ending with a rectangular tube housing quadruple cruciform braking parachutes. Under the wing was the enor-

mous box housing the air-inlet systems and the four single-shaft RD-36-41 turbojets, each with an afterburning rating of 16,000kg (35,273 lb). An automatic FBW system governed the engines and their three-section variable nozzles and variable-geometry inlets. Each main landing gear had four twin-tyred wheels and retracted forwards, rotating 90° to lie on its side outboard of the engine duct. The nose gear had levered suspension to two similar tyres, with wheel brakes, and used the hydraulic steering as a shimmy damper. It retracted backwards into a bay between the engine ducts. The four autonomous hydraulic systems were filled with KhS-1 (similar to Oronite 70) and operated at the exceptional pressure of 280kg/cm² (3,980 lb/in²). A liquid oxygen system was provided, together with high-capacity environmental systems which rejected heat to both air and fuel. The crew wore pressure suits. The main electrical system was generated as 400-Hz three-phase at 220/115 V by four oil-cooled alternators rated at 60 kVA. Aircraft 101 never received its full astro-inertial navigation system, nor its planned 'complex' of electronic-warfare, reconnaissance and weapon systems. The latter would have included two Kh-45 cruise missiles, developed by the Sukhoi OKB, with a range of 1,500km (932 miles).

Like the B-70 this was a gigantic programme which broke much new ground (the OKB said '200 inventions, or 600 if you include manufacturing processes') yet which was finally judged to have been not worth the cost.

| | | |
|------------------------|---------------------|-----------------------|
| Dimensions | | |
| Span | 22.00m | 72 ft 2 in |
| Length | 44.50m | 146 ft |
| Wing area | 295.7m ² | 3,183ft ² |
| Weights | | |
| Empty (as rolled out) | 54,600kg | 120,370 lb |
| (equipped) | 55,600kg | 122,575 lb |
| Loaded (normal) | 114,400kg | 252,205 lb |
| (maximum) | 136 tonnes | 299,824 lb |
| Design Performance | | |
| Max and cruising speed | 3,200 km/h | 1,988 mph (Mach 3.01) |
| at sea level | 1,150km/h | 715 mph (Mach 0.94) |
| Service ceiling | 24km | 78,740 ft |
| Range | at 3,000 knYh | 1,864 mph (Mach 2.82) |
| (clean) | 6,000 km | 3,728 miles |
| (drop tanks) | 7,000km | 4,350 miles |
| Take-off run | | |
| (normal loaded weight) | 1,000m | 3,281 ft |
| Landing speed/run | 260 km/h | 161.6 mph |
| with parachutes | 950m | 3,117ft |

- 1: Hinged nose

2: Pilot's cockpit

3: Entry hatch

4: Foreplane

5: Navigator's cockpit

6: Entry hatch

7: Pressurized electronics bay

8: Forward fuel tank

9: Mechanical, electrical and fuel services

10: Main fuel tanks

11: Aft fuel tank

12: Rear spar

13: Elevon

14: Fin

15: Tail trimming tank

16: Fin antennas
- 17: Rudder power units

18: Upper rudder

19: Brake-parachute compartment

20: No1 engine

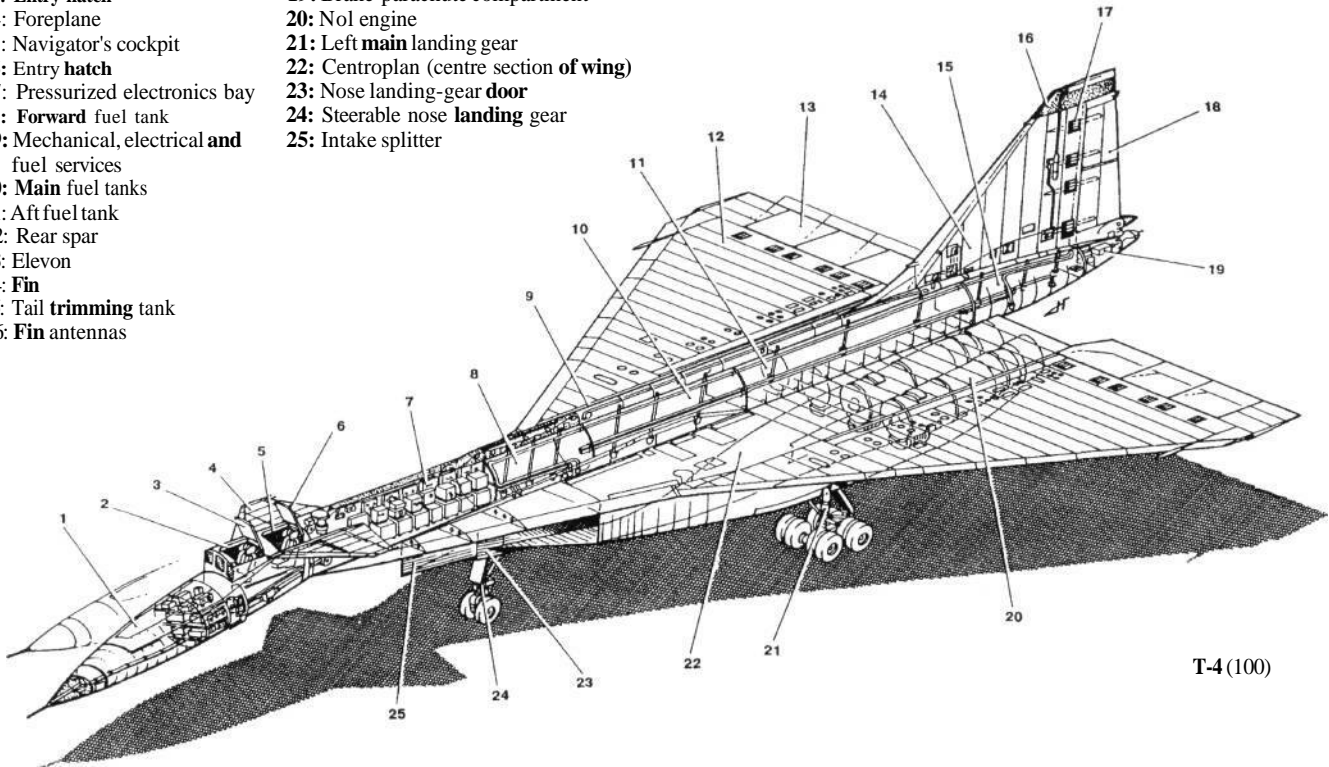
21: Left main landing gear

22: Centroplan (centre section of wing)

23: Nose landing-gear door

24: Steerable nose landing gear

25: Intake splitter



T-4 (100)

Sukhoi 100L

Purpose: To test wing forms for the 100 aircraft.

Design Bureau: P O Sukhoi, Moscow.

Another of the aircraft used to provide research support for the 100, or T-4, was this modified Su-9 interceptor. In the period 1966-70 this aircraft was fitted with a succession of different wings. Most testing was done at LII Zhukovskii.

The 100L was originally a test Su-9, with side number (callsign) Red 61 (the same as for the T6-1, and also for the first two-seat MiG-21, but this had finished testing at LII before the 100L arrived). The aircraft was fitted with telemetry with a diagonal blade antenna under the nose, but apparently not with a cine camera at the top of the fin. The various test wings were manufactured by adding to the existing Su-9 wing box, in most cases ahead of the wing box only. The first experimental wing was little changed in plan view: the wing was given an extended sharp leading edge which extended the tip to a point. Three further wings with sharp leading edges were

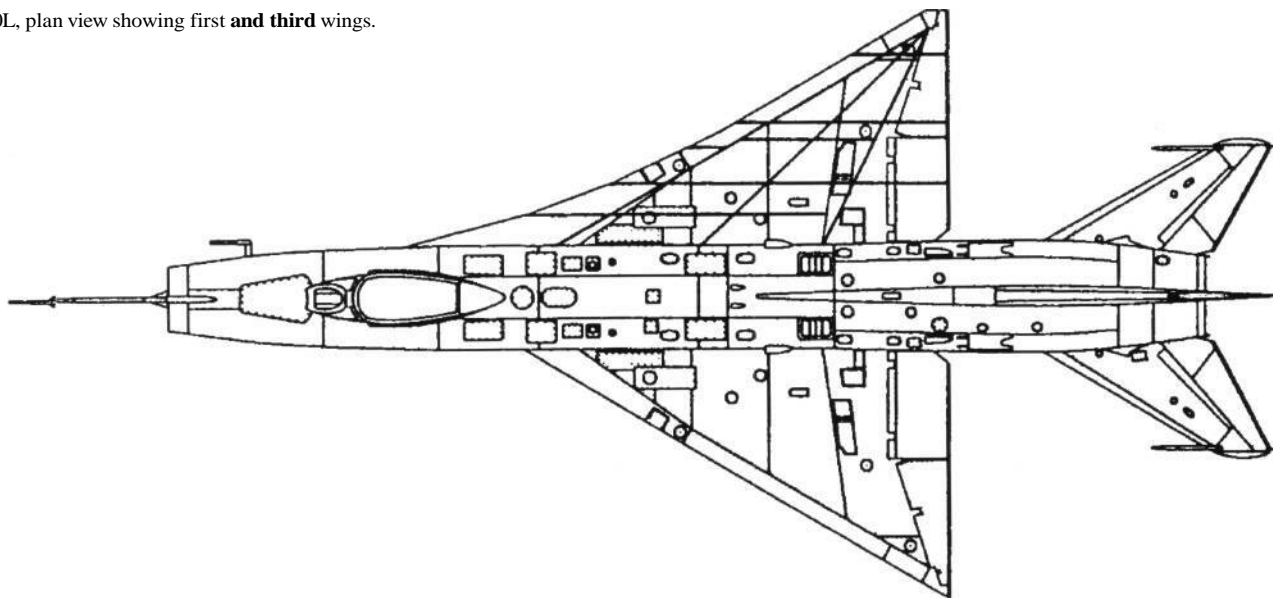
tested, as well as one with a 'blunt leading edge'. This meant that it was the sharply swept inboard leading edge that was blunt, because at least one of the wings was fitted with a leading edge which in four stages increased in sweepback from tip to root to meet the fuselage at 75°. All the test wings had perforated leading edges from which smoke trails could be emitted. Further testing was done with a sharp-edged horizontal tail.

Results from this aircraft were aerodynamic, not structural, but they materially assisted the design of the 100.

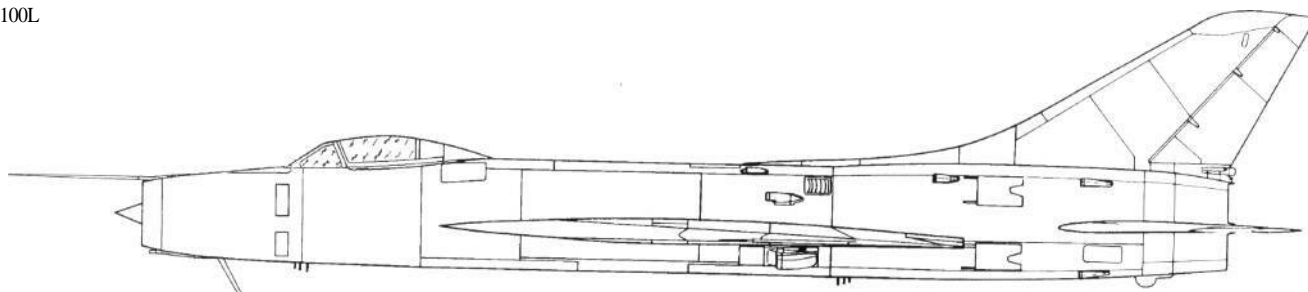
100L'Red 61'test bed.

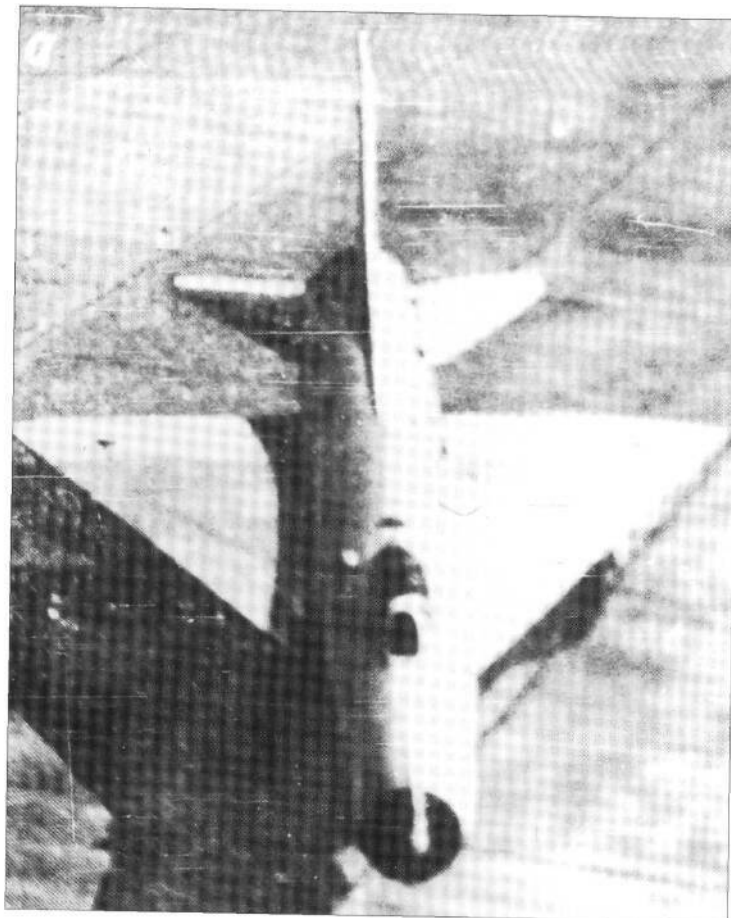
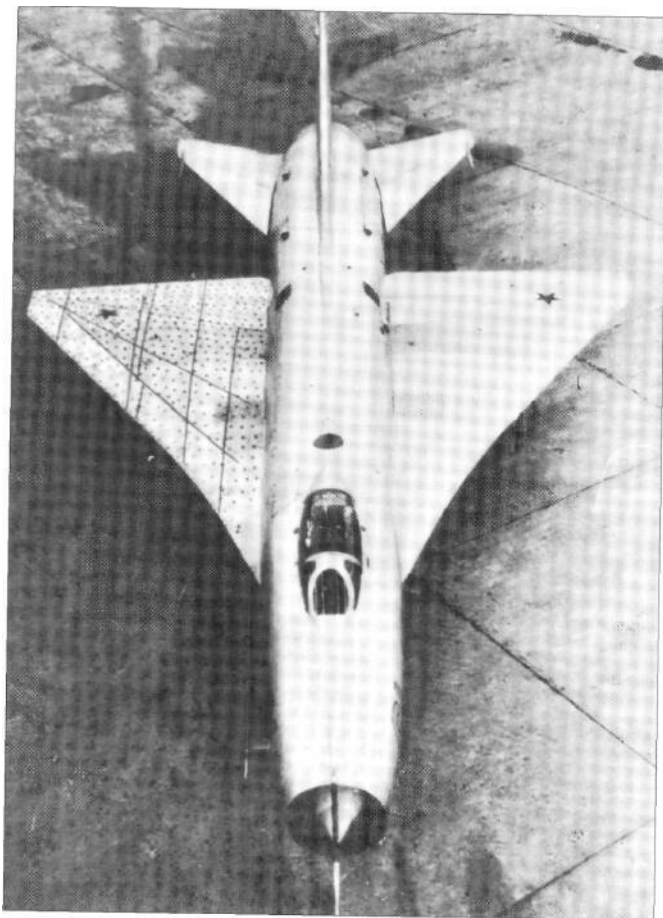


100L, plan view showing first and third wings.



100L





Two views of the 100L with different wings.

Sukhoi 100LDU

Purpose: To flight-test canard surfaces.
Design Bureau: P O Sukhoi, Moscow

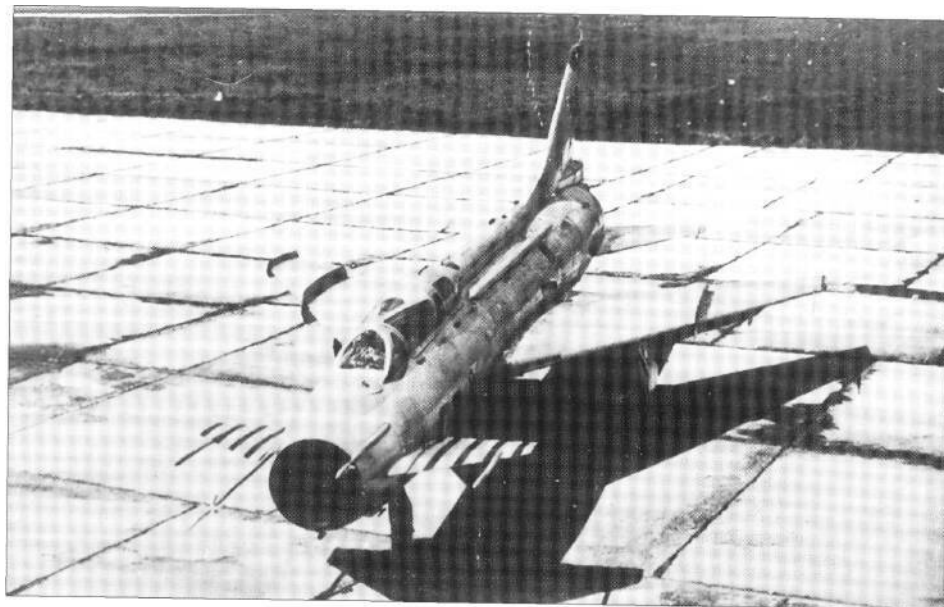
As explained in the history of the T-4, this enormous project required back-up research right across Soviet industry. The Sukhoi OKB

itself took on the task of investigating the proposed canard surfaces. As the only vehicle immediately available was a two-seat Su-7U, with a maximum Mach number of 2 instead of 3, the resulting aircraft - with designation 100LDU - ceased to be directly relevant to the

T-4 and became instead a general canard research vehicle. It was assigned to LII-MAP test pilot (and future Cosmonaut) Igor Volk, and was tested in 1968-71.

The basic Su-7U, powered by an AL-7FI-200 with a maximum afterburning rating of 10,100kg (22,282 lb), was subjected to minor modifications to the rudder and braking-parachute installation, and was fitted with fully powered canard surfaces on each side of the nose. These were of cropped delta shape, with a greater span and area than those of contemporary experimental MiG aircraft, and with anti-flutter rods which were longer and nearer to the tips.

This aircraft fulfilled all test objectives, though the numerical data were of only marginal assistance to the T-4/100 design team.



100LDU

Sukhoi 02-10, or L02-10

Purpose: To investigate direct side-force control.

Design Bureau: P O Sukhoi, Moscow.

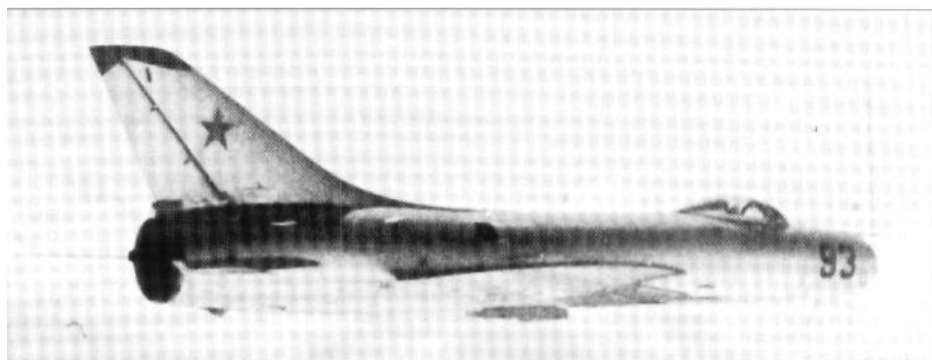
In 1969 this Su-9 was modified for the LII, which wished to investigate the application of direct side force. The LII had been concerned at American research into direct lateral or vertical force which could enable a fighter to rise, fall, move left or move right without changing the aircraft's attitude. In other words such an aircraft could keep pointing at a target in front while it crabbed sideways (for example). Testing began in 1972. In 1977 the aircraft was returned to a Sukhoi OKB factory and had the upper nose fin removed, testing continuing as a joint LII/Su programme. It was further modified in 1979.

Originally this aircraft was a production Su-9 interceptor, though it never saw active service. In its first 02-10 form it had substantial vertical fins added above and below the nose. Each fin was pivoted at mid-chord and fully

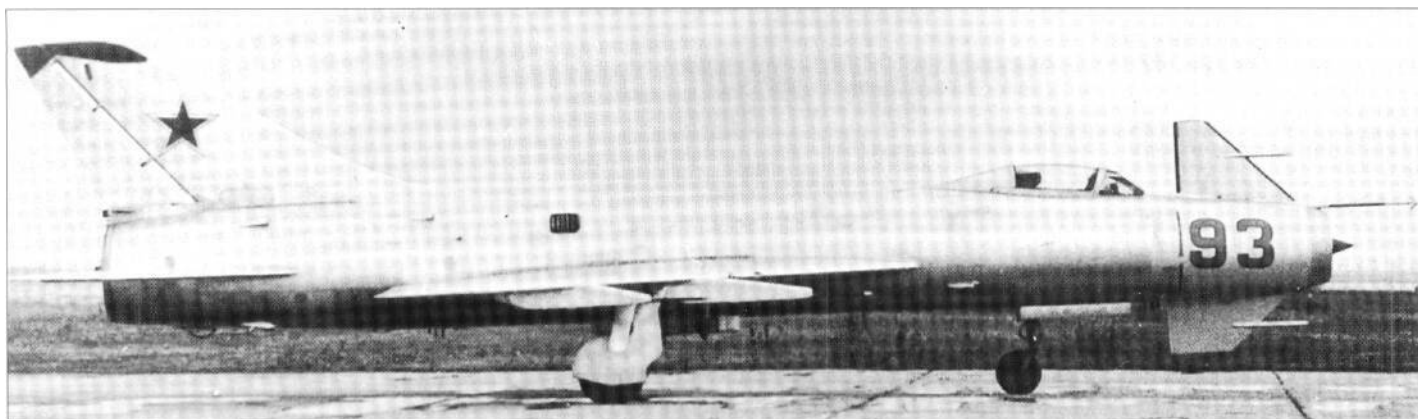
powered. The pilot was able to cut the nose fins out of his flight-control circuit, leaving them fixed at zero incidence. When they were activated, movement of his pedals drove the fins in unison with each other and in unison with the rudder. The two canard fins moved parallel to the rudder, to cause the aircraft to crab sideways. Each surface was of cropped delta shape, with a lower aspect ratio than the horizontal canards of the S-22PDS. Compared with the lower fin the upper surface had significantly greater height, and it was mounted slightly further forward. Each was fitted with an anti-flutter rod mass,

which during the course of the programme was moved from 40 per cent of fin height (distance from root to tip) to 70 per cent. After the 02-10's first series of tests the upper nose fin was removed (leaving its mounting spigot still in place). Later a cine camera was installed on the fin to record lateral tracking across the ground, and in some of the later tests the wings were fitted with smoke nozzles along the leading edge, to produce visible streamlines photographed by a camera in a box immediately ahead of the radio antenna.

This aircraft generated useful information, but the idea has never been put into practice.



Three different versions of L02-10 test-bed.



Sukhoi T6-1

Purpose: To create a superior tactical attack bomber.

Design Bureau: P O Sukhoi, Moscow.

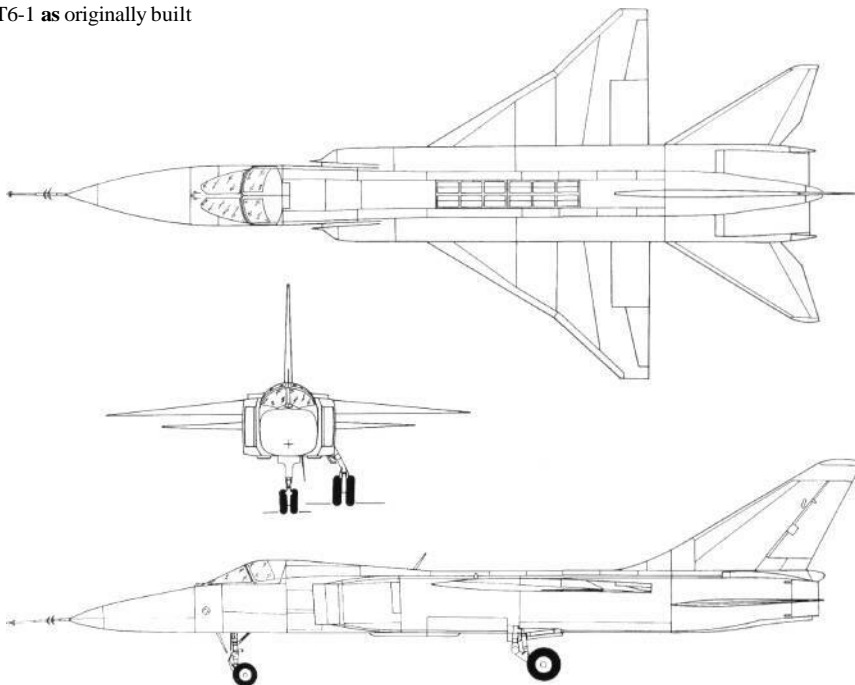
As noted in the story of the S-22I (S-32), publication of the formidable requirements for the USAF's TFX programme spurred a response by the USSR. These requirements called for long range with a heavy bombload and the ability to make a blind first-pass attack at supersonic speed at low level 'under the radar'. There was obvious need to replace the IL-28 and Yak-28, and the task appeared to call for either the use of a battery of special lift engines or a VG (variable-geometry, ie variable-sweep) wing. Sukhoi OKB was entrusted with this important task, and took a 'belt and braces' approach. To get something flying quickly it decided to put VG wings on the outstanding Su-7B, resulting in the S-22I described previously. For the longer term it launched development of a new aircraft, the S-6. This was first drawn in 1963, and it was to have a fixed swept wing, two Metskvarichvili R-21F-300 engines each with a wet afterburning rating of 7,200kg (15,873 lb), pilot and navigator seated in tandem, and the Puma navigation and weapon-delivery system. Five hardpoints were to carry a load of 3 tonnes (6,614 lb), take-off weight being 20 tonnes (44,090 lb), and maximum speed was to be 1,400km/h (870mph) at very low level and 2,500km/h (1,553mph, Mach 2.35) at high altitude. Short-take-off capability was to be provided by two large take-off rockets. As a cover, and to assist

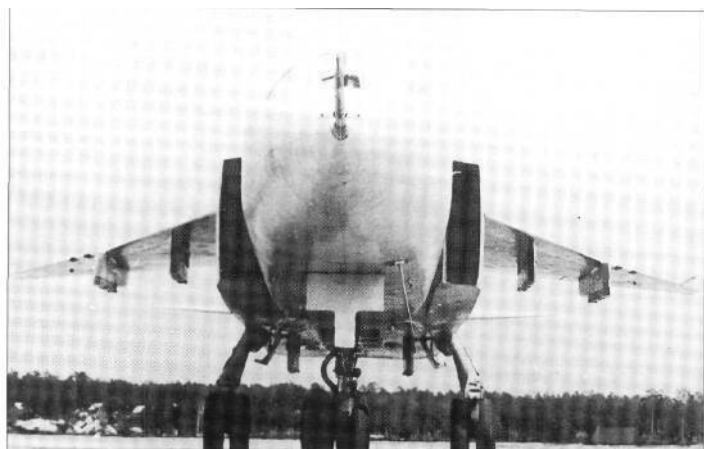
in obtaining funds more quickly, the S-6 was redesignated T-58M to look like a member of that interceptor family, but in 1964 it was terminated. This was partly because of intractable problems with the engine (see MiG Ye-8), and partly because of the good progress with the T-58VD (see previous). In early 1965 the S-6 was replaced by the T-6, later written T6. This was a significantly larger and more powerful aircraft, even surpassing the F-111, which was in production by then. After rollout it was given the callsign Red 61 and first flown by the chief test pilot, Vladimir S Ilyushin, on 2nd July 1967. It was fitted with a battery of lift jets, as in the T-58VD, and it was immediately found that (as before) these caused aerodynamic and control difficulties. In 1968 the R-27 main engines were removed and the complete rear fuselage and powerplant systems modified to take the Lyul'ka AL-21F engine, with a maximum afterburning rating of 11,200kg (24,691 lb). To improve directional stability the wingtips were tilted sharply down in TSR.2 fashion, the anhedral being 72°. Large strakes were added on each side of the rear fuselage, and the airbrakes deleted. To meet the needs of radar designers the nose radome was made shorter, with no significant effect on drag, and over the years numerous flush antennas and fairings appeared. Even after the decision was taken to change the design to have high-aspect-ratio 'swing wings' the T6-1 continued testing systems and equipment. In 1974, having made over 320 test flights, it was retired to the WS Museum at Monino.

In fact, the design of the T6-1 had been even more strongly influenced by the British TSR.2, with a fixed-geometry delta wing of short span and large area and fitted with powerful blown flaps. Before the first aircraft, the T6-1, was built the wing was modified with the leading-edge angle reduced from 60° to 45° outboard of the flaps, ahead of the conventional ailerons. As originally built, the large fuselage housed two Khachaturov (Tumanskii KB) R-27F2-300 engines each with a wet afterburning rating of 9,690kg (21,365 lb), fed by sharp-edged rectangular side inlets with an inner wall variable in angle and throat area. Downstream of the inlets the fuselage had a broad box-like form able to generate a considerable fraction of the required lift at supersonic speed at low level. Ahead of the inlets was an oval-section forward fuselage housing two K-36D seats side-by-side, as in the F-111, an arrangement which was considered an advantage in a first-pass attack and also to assist conversion training in a dual version. There were left and right canopies each hinged upward from the broad spine downstream. The width of the cockpit left enough space between the engine ducts for a considerable fuel tankage as well as two pairs of RD-36-35 lift jets, installed in a single row as in the T-58VD. No attempt was made to bleed any engines to provide air for reaction-jet controls, because the T6-1 was not designed to be airborne at low airspeeds. The one-piece tailplanes were in fact tailerons, driven individually by KAU-125 power units to provide control in roll as well as pitch. For operation from unpaved strips the levered-suspension main landing gears had twin wheels with tyres 900 x 230mm, retracting forwards into bays under the air ducts, while the steerable nose gear again had twin wheels, 600 x 200mm, with mudguards, retracting to the rear. At the extreme tail an airbrake was provided on each side, requiring a cutaway inboard trailing edge to the tailplanes, and between the jet nozzles under the rudder was a cruciform braking parachute. For the first time the avionics were regarded as a PNK, a totally integrated navigation and attack 'complex', and the T6-1 played a major role in developing this. It was fitted with four wing pylons with interfaces for a wide range of stores, as well as two hardpoints inboard of the main-gear bays, the maximum bombload being 5 tonnes (11,020 lb). The production Su-24 has eight hardpoints for loads up to 8 tonnes (17,637 lb).

The T6-1 was a stepping-stone to a family of powerful and formidable aircraft which in 2000 are still in service with Russia and Ukraine. Unquestionably, the lift jets were not worth having.

T6-1 as originally built





Dimensions

| | | |
|----------------------|------------------|---------------------|
| Span | 9.2m | 30 ft Kin |
| Length (as modified) | 23.2m | 76ftP/4in |
| Wing area | 51m ² | 550 ft ² |

Weights

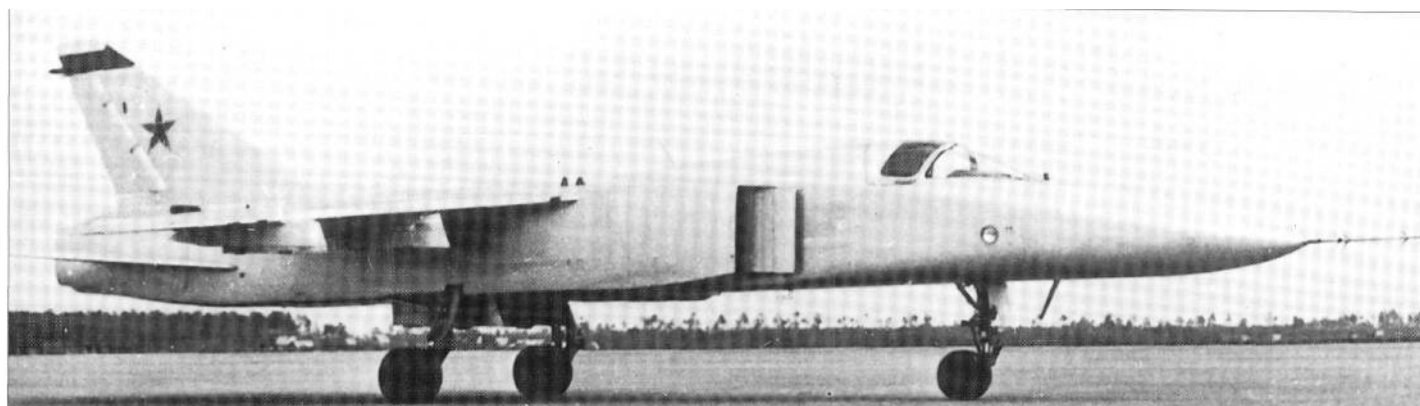
| | | |
|--------------------------------------|-----------|-----------|
| Empty not reported | | |
| Loaded (normal) | 26,100kg | 57,540lb |
| (maximum) | 28 tonnes | 61,728 lb |
| The production Su-24MK is cleared to | 39,700 kg | 87,522 lb |

Performance

| | | |
|---------------------------------------|-------------|-------------------|
| Max speed at sea level | 1,468km/h, | 912mph(Mach1.2) |
| at high altitude | 2,020 km/h, | 1,255mph(Mach1.9) |
| Take-off field length (normal weight) | 350m | 1,148ft |

Top: T6-1 after modification.

Above left, right and below: Three views of T6-1 as originally built



Sukhoi T-10

Purpose: To create a superior heavy fighter.

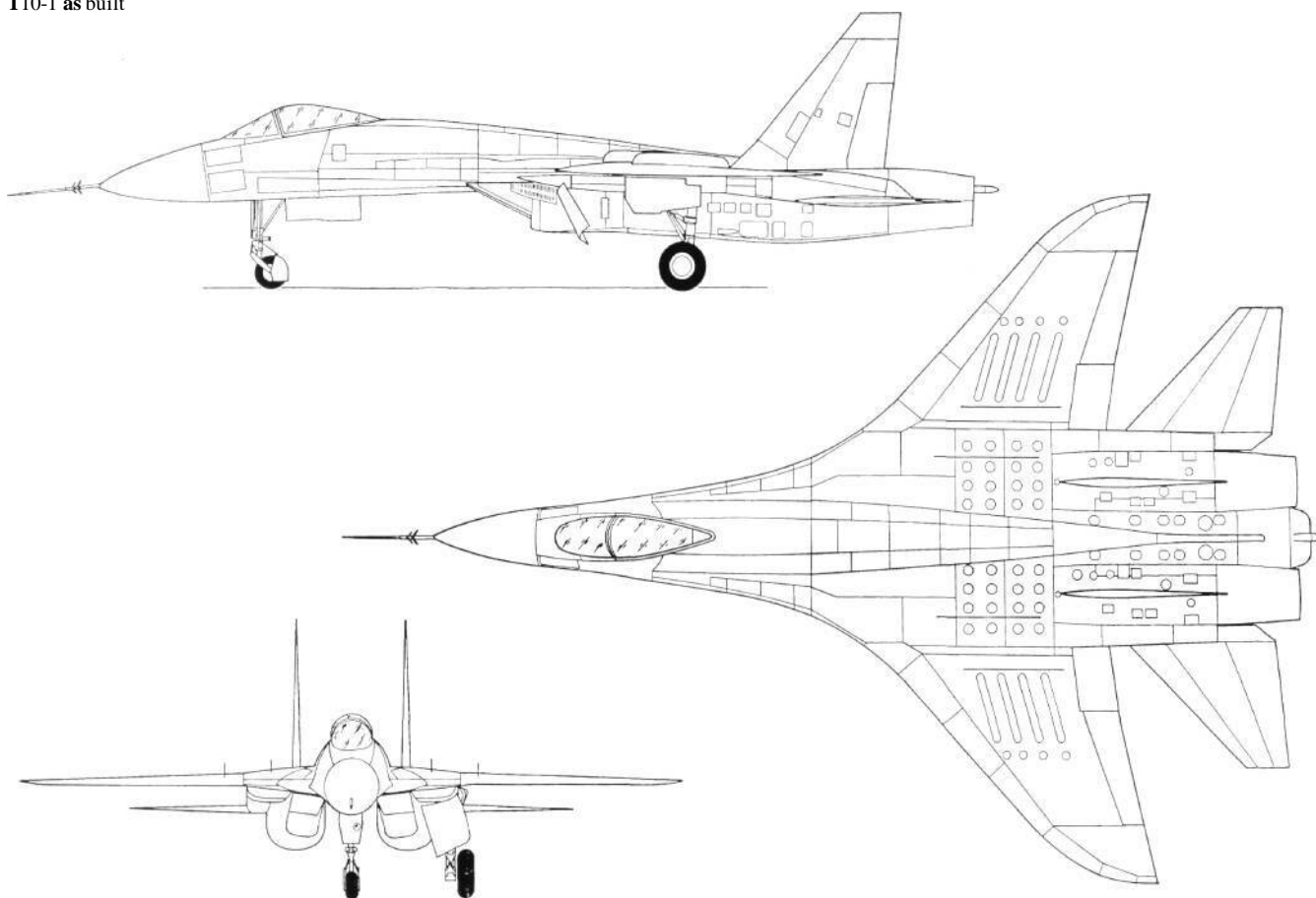
Design Bureau: P O Sukhoi, Moscow.

In 1969 the IA-PVO, the manned interceptor defence force, issued a requirement for a totally new heavy interceptor. This was needed to replace the Tu-128, Yak-28P and Su-15 in defending the USSR against various cruise missiles, as well as the F-111 and other new Western fighters and tactical aircraft. A specific requirement was to combine long-range standoff-kill capability with performance and combat agility superior in a close dogfight to any Western aircraft. The formal competition was opened in 1971. Though Mikoyan and Yakovlev were invited to participate, all the running was made by Sukhoi OKB, which was eager to move on from the T-4 and get a new production aircraft. With Sukhoi himself semi-retired, Yevgenii Ivanov was appointed chief designer, with Oleg Samolovich deputy. Sukhoi's two rival OKBs made proposals, but did not receive contracts to construct prototype aircraft to meet this requirement (though the standoff-kill demand was also addressed by the later MiG-25P variants and MiG-31).

Sukhoi submitted two alternative proposals. Both were broadly conventional single-seat twin-engined aircraft with 'ogival Gothic' wings (almost delta-shape but with a double-curved leading edge) and horizontal tails, the only new feature being twin vertical tails. One had side air inlets with horizontal ramps, while the other proposal had a fuselage blended into a wing mounted underneath and two complete propulsion systems mounted under the wing. A detail was that both had outstanding pilot view with a drooped nose and bulged canopy. As the wing was more akin to a delta than to a swept wing the project was given the designation T-10 in the T series (see T-3). The competitive design review was won by Sukhoi in May 1972. CAHI (TsAGI) had tunnel-tested T-10 models from 1969, and the work built up each year until 1974, demanding more tunnel testing than any previous Soviet aircraft except the Tu-144. It was the unconventional configuration that was chosen, with the fuselage tapering to nothing above the wing and being replaced by large engine gondolas underneath. Drawings for the first prototype, the

T10-1, were issued in 1975. Construction was handled by the OKB factory, except for wing and tail surfaces which were made at the OKB's associated huge production facility named for Cosmonaut Yuri Gagarin at Komsomolsk-na-Amur in Siberia. Vladimir Ilyushin began a successful flight-test programme on 20th May 1977. Investigation of basic handling, including high-AOA (angle of attack) flight, was completed in 38 flights by late January 1978. Four wing fences were added, together with anti-flutter rods on the fins and tailplanes. Many further flights explored the FEW (fly-by-wire) flight controls and, after fitting no fewer than seven hard-points where pylons could be attached, the weapons control system. Red 10 was finally put on display in the Monino Museum. T10-2 began flying at the beginning of 1978, but a software error led to unexplored resonance which caused inflight breakup, killing Evgeny Solov'yov. By 1978 the OKB was busy with T10-3, the first prototype fitted with the definitive engine, and this was flown by Ilyushin on 23rd August 1979. In 1982 T10-3 was flown by OKB pilot Nikolai Sadovnikov from a simulated

T10-1 as built



aircraft-carrier ramp, and it later made hook-equipped simulated carrier landings. T10-4, first flown by Ilyushin on 31st October 1979, tested the new engines and avionics. So great was the need to test avionics that the Komsomolsk factory was contracted to build five further prototypes. These were designated T10-5, -6, -9, -10 and -11 (T10-7 and -8 were significantly modified). These additional prototypes were generally similar to T10-3, apart from the fact that the fins were canted outwards. The T10-5 flew in June 1980, and the remainder were all on flight test by autumn 1982. Pavel Sukhoi died on 15th September 1975, and was succeeded as General Constructor by Mikhail P Simonov. Soon after he took over, the first detailed information on the McDonnell Douglas F-15 became available. Computer simulations found that the T-10 did not meet the requirement that it should be demonstrably superior to the USAF aircraft. Simonov ordered what amounted to a fresh start, telling the author 'We kept the wheels and ejection-seat'. Designated T-10S, from Seriyinii, production, the new fighter can only be described as brilliant. Ever since the first pre-series example, the T10-17, was flown by Ilyushin on 20th April 1981 it has been the yardstick against which other fighters are judged. An enormous effort was made by Nil using T10-17 and T10-22 to clear the re-designed aircraft for production. The first true series aircraft, designated Su-27, was flown at Komsomolsk in November 1982.

The T-10 wing had 0° dihedral, and a symmetric profile with a ruling thickness/chord ratio of 3.5 per cent, rising to 5 per cent at the root. The leading edge was fixed. It left the fuselage with a sharp radius and with a sweep angle of 79°, curving round to 41° over the outer panels and then curving back to Kiichemann tips. The main torsion box had three spars and one-piece machined skins. Most of the interior was pressurized and formed an integral tank, while high-strength ribs carried armament suspension points. The oval-section fuselage forward section was designed to accommodate the intended large radar, followed by the cockpit with a sliding canopy. Behind this came an equipment bay, followed by a humpbacked 'forecastle tank' and then a broad wing centre-section tank which could be considered as part of both the wing and fuselage. A further tank was placed in the keel beam between the engines. The latter were of the Lyul'ka AL-21F-3 type, each with an afterburning rating of 11,200kg (24,691 lb). Each was placed in a large nacelle or gondola under the wing, tilted outward because of the inboard wing's sharp taper in thickness. Each engine air duct was fed by a wedge inlet behind the leading edge, standing well away under the wing's underskin to avoid swallow-

ing boundary-layer air. Each inlet contained a variable upper ramp, with auxiliary side inlets for use on take-off, and a curved lower portion. The large engine gondolas provided strong bulkheads on which were mounted the two vertical fins and the tailplanes. The AL-21 had its accessories mounted on top, and the massive structure and fins immediately above made access difficult. From the third aircraft the engine was the Lyul'ka AL-31F, which had been specially designed for this aircraft. It had an afterburning rating of 12,500kg (27,557 lb), and offered several other advantages, one being that it was half a tonne (1,100 lb) lighter than the AL-21F. It had its accessories partly underneath and partly far forward on top, and the vertical tails were moved outboard away from the engine compartments. The main landing gears had large (1,030 x 350mm) tyres on single legs and retracted forwards, rotating the wheel through 90° to lie flat in the root of the wing in a bay closed by side doors and large front doors which served as airbrakes. The tall nose gear had a single unbraked wheel with a 680 x 260mm tyre. It retracted backwards, and was fitted with an all-round mudguard to protect the engine inlets. The main-wheel wells required a thick inboard section of the wing adjacent to the engine gondolas, and this was carried to the rear to provide strong beams to which the tailplanes (and in the redesigned aircraft the fins) were pivoted. The T-10 flight controls comprised conventional ailerons, two rudders and the independently controlled tailplanes. All these surfaces were driven by power units each served by both the completely separated 210kg/cm² (2,987 lb/in²) hydraulic systems. These systems also drove the plain flaps, landing gears (with independent airbrake actuation), nosewheel steering,

engine inlets and mainwheel brakes. The fly-by-wire system governed pitch control by the tailplanes used in unison, and provided three-axis stabilization. The mechanical controls worked directly by the pilot's linkages to the surface power units governed the ailerons and rudder. The five internal fuel tanks were automatically controlled to supply fuel without disturbing the aircraft centre of gravity. A special oxygen system was provided to ensure engine restart and afterburner light-up at high altitude. T10-1 was built with no provision for armament, but in its modified state it had seven hardpoints on which external stores could be suspended.

Despite the fact that the basic aircraft had to be completely redesigned, the T-10 family of prototypes were stepping stones to the greatest fighter of the modern era.

| Dimensions (T10-1 as built) | | |
|-----------------------------|---------------------|----------------------|
| Span | 14.7m | 48 ft 2½ in |
| Length | 19.65m | 64 ft 5½ in |
| Wing area | 59.0 m ² | 635 ft ² |
| Weights | | |
| Weight empty | 18,200kg | 40,123 lb |
| Loaded | 25,740kg | 56,746 lb |
| Performance | | |
| Max speed at sea level, | 1,400km/h | 870 mph (Mach 1.145) |
| at high altitude; | 2,230 km/h | 1,386 mph (Mach 2.1) |
| Service ceiling | 17,500m | 57,415ft |
| Range | 3,100km | 1,926 miles |

T10-1 after modernization.



Sukhoi P-42

Purpose: To modify a T-10 (Su-27) to set world records.

Design Bureau: P O Sukhoi, Moscow, General Constructor M P Simonov.

According to Simonov, The idea of entering a competition for world records for aircraft of this category was conceived during 1986. We realised that this aircraft was capable of doing many things. We were so confident that, for record setting, we decided not to build a dedicated aircraft but took one of the pre-series ones which had already flown. This then had to be prepared in conformity with the stringent Federation Aeronautique Internationale rules. The aircraft was called the P-42 as a tribute to the turning point in the Stalingrad battle in November 1942, when Soviet aviation had played a large part in crushing the enemy'. The OKB organised a team of design engineers, test pilots and supporting ground staff under Chief Designer Rollan G Martirosov (who later designed Ekranoplans). The modified aircraft was ready in October 1986. In two flights, on 27th October and 15th November 1986 Viktor Pugachev set eight climb-to-altitude records (four absolute and four for aircraft of up to 16 tonnes take-off weight): he reached 3km (9,843ft) in 15.573

seconds and 6km (19,685ft) in 37.05 seconds. On 10th March 1987 and 23rd March 1988 Nikolai Sadovnikov flew the P-42 to 9km (29,528ft) in 44.0 seconds, to 12km (39,370ft) in 55.20 seconds and to 15km (49,213ft) in 70.329 seconds. On 10th June 1987 Sadovnikov set a world class record by sustaining an altitude of 19,335m (63,435ft) in level flight. Another record set by Pugachev was lifting a load of 1 tonne (2,205lb) to 15km (49,213ft) in 81.71 seconds.

The aircraft selected was T10-15. It was simplified and its weight reduced until it was able to take off at a weight of 14,100kg (31,085lb). With AL-31F engines uprated to 13,600kg (29,982lb) this gave a thrust/weight ratio of 1.93, believed to be the highest of any aircraft ever built. Modification to the equipment included removal of the radar and military equipment (including the GSh-301 gun and its ammunition container, wingtip missile launchers and weapon hardpoints) and removal of avionics other than the flight, navigation and communications needed for safe flight. Modifications to the airframe included replacement of the nose radome by a metal fairing, simplification of the wings by installing a fixed leading edge and a fixed structure in place of the flaperons, removal of the

ventral fins and the tops of the fins, replacement of the airbrake by a fairing and simplification of the airbrake supporting structure, removal of the parabake container, simplification of the variable engine inlets which were locked in their optimum positions, and removal of the mudguard from the nose-wheel. The aircraft was left unpainted.

The P-42 set a total of 27 world records.



Sukhoi T10-24

Purpose: To evaluate Su-27 foreplanes.

Design Bureau: P O Sukhoi, Moscow, General Designer M P Simonov.

In 1977 Simonov authorised studies into the possibility of adding foreplanes (canard surfaces) to the Su-27. Such surfaces appeared to offer improved controllability, especially in extreme manoeuvres at high AOA (angle of attack), when flight testing had shown that the tailerons were in the wake of the wing. Following tunnel testing of models work continued in 1979 in collaboration with CAHI

(TsAGI). This research revealed that in some flight conditions there were longitudinal-control problems. A canard system free from these problems was devised in 1982, and in May 1985 flight testing of the T10-24 began.

The T10-24 was fitted with the PGO (Peredneye Gorizontallye Opereniye, front horizontal tail). After prolonged research this was fitted not on the forward fuselage, as in most other canard aircraft, but to the leading edges of the modified centroplan (centre wing). The two surfaces had a cropped-delta plan shape, with a thickness/chord ratio of 3 per

cent, and they were mounted horizontally and pivoted at about 60 per cent root chord. They were driven by power units linked to the FBW flight-control system. Depending upon the flight regime they increased stability in pitch and roll and also instability in pitch. They significantly reduced trim drag, and they increased the maximum attainable lift coefficient (at an AOA of 30°) from 1.75 to 2.1.

Testing the T10-24 substantiated the predicted advantages and supported development of later fighters, beginning with the naval Su-27K.



Sukhoi Su-37

Purpose: To create the optimised multirole fighter derived from the Su-27.

Design Bureau: AOOT 'OKB Sukhoi', Moscow.

The superb basic design of the T-10 led not only to the production Su-27 but also to several derivative aircraft. Some, such as the Su-34, are almost completely redesigned for new missions. One of the main objectives has been to create even better multirole fighters, and via the Su-27UB-PS and LMK 24-05 Sukhoi and the Engine KB 'Lyul'ka-Saturn' have, in partnership with national laboratories and the avionics industry, created the Su-37. The prototype was the T10M-11, tail number 711, first flown on 2nd April 1996. The engine nozzles were fixed on the first flight, but by September 1996, when it arrived at the Farnborough airshow, this aircraft had made 50 flights with nozzles able to vector. At the British airshow it astounded observers by going beyond the dramatic Kobra manoeuvre and making a complete tight 360° somersault essentially within the aircraft's own length and without change in altitude. Called Kulbit (somersault), this manoeuvre has yet to be emulated by any other aircraft. In 1999 low-rate production was being planned at Komsomolsk.

Essentially the Su-37 is an Su-35 with vectoring engines. Compared with the Su-27 the Su-35 has many airframe modifications including canards, taller square-top fins (which are integral tanks) and larger rudders, double-slotted flaps, a bulged nose housing the electronically scanned antenna of the N011M radar, an extended rear fuselage housing the aft-facing defence radar, twin nosewheels and, not least, quad FBW flight controls able to handle a longitudinally unstable aircraft. In addition to these upgrades the Su-37 has AL-31FP engines, each with dry and augmented thrust of 8,500 and 14,500kg (18,740 and 31,967lb) respectively. These engines have efficient circular nozzles driven by four pairs of actuators to vector $\pm 15^\circ$ in pitch. Left/right vectoring is precluded by the proximity of the enlarged rear fuselage, but engine General Designer Viktor Chepkin says 'Differential vectoring in the vertical plane is synonymous with 3-D multi-axis nozzles'. In production engines the actuators are driven by fuel pressure.

It is difficult to imagine how any fighter with fixed-axis nozzles could hope to survive in any kind of one-on-one engagement with this aircraft.

| Dimensions | | |
|----------------------------|--------------------|-----------------------|
| Span (over ECM containers) | 15.16m | 49 ft 8½ in |
| Length | 22.20m | 72 ft 10 in |
| Wing area | 62.0m ² | 667ft ² |
| Weights | | |
| Weight empty | 17 tonnes | 37,479 lb |
| Maximum loaded | 34 tonnes | 74,956 lb |
| Performance | | |
| Maximum speed | | |
| at sea level | 1,400km/h | 870mph (Mach 1.14) |
| at high altitude | 2,500km/h | 1,553 mph (Mach 2.35) |
| Rate of climb | 230 m/s | 45,276 ft/min |
| Service ceiling | 18,800m | 61,680ft |
| Range (internal fuel) | 3,300 km | 2,050 miles |

Below: T10M-11.



Sukhoi S-37 Berkut

Purpose: To provide data to support the design of a superior air-combat fighter.

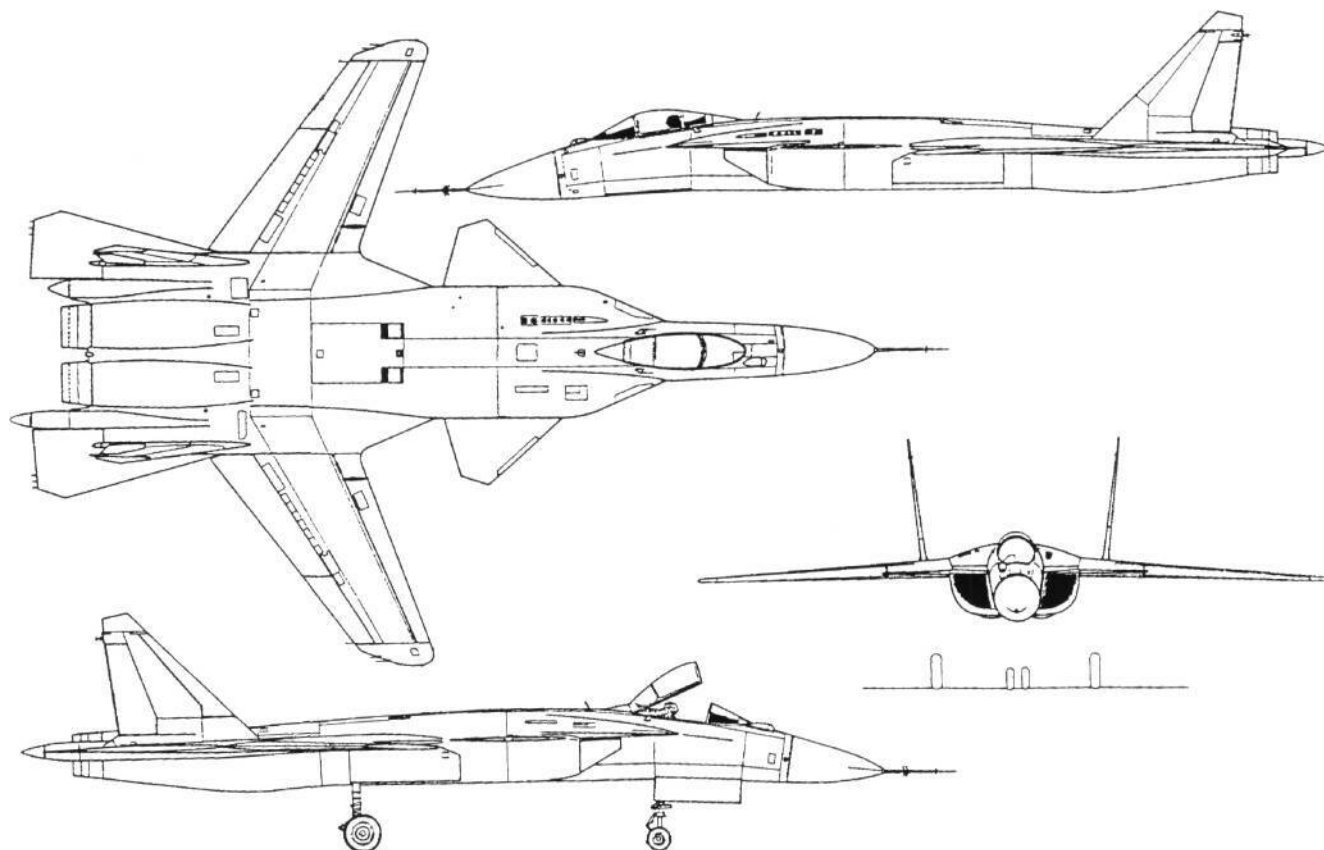
Design Bureau: AOOT 'OKB Sukhoi', Moscow.

Almost unknown until its first flight, this aircraft is one of the most remarkable in the sky. Any impartial observer cannot fail to see that, unless Sukhoi's brilliance has suddenly become dimmed, it is a creation of enormous importance. Like the rival from MiG, it provides the basis for a true 'fifth-generation' fighter which with rapid funding could swiftly become one of the greatest multirole fighters in the world. Unfortunately, in the Russia of today it will do well to survive at all, especially as the WS has for political and personality reasons shown hostile indifference. In fact on 1st February 1996, when the first image of a totally new Sukhoi fighter leaked out in the form of a fuzzy picture of a tabletop model, the WS Military Council instantly proclaimed that this aircraft 'is not prospective from the point of view of re-equipment within 2010-25'. In fact the first hint of this project came during a 1991 visit by French journalists to CAHI (TsAGI), when they were shown a

model of an aircraft with FSW (forward-swept wings) and canard foreplanes called the Sukhoi S-32. At the risk of causing confusion, Sukhoi uses S for projects and Su for products, the same number often appearing in both categories but for totally different aircraft (for example, the Su-32 is piston-engined). In December 1993, during the Institute's 75th-birthday celebrations, its work on the FSW was said to be 'for a new fighter of Sukhoi design'. The model shown in February 1996 again bore the number '32' but clearly had tailplanes as well as canards. It had been known for many years that the FSW has important aeroelastic advantages over the traditional backswept wing (see OKB-1 bombers and Tsybin LL). At least up to Mach 1.3 (1,400 to 1,500 km/h, 870 to 930 mph) the FSW offers lower drag and superior manoeuvrability, and the lower drag also translates as longer range. A further advantage is that take-offs and landings are shorter. The fundamental aeroelastic problem with the FSW can be demonstrated by holding a cardboard wing out of the window of a speeding vehicle. A cardboard FSW tends to bend upwards violently, out of control. An FSW for a fast jet was

thus very difficult to make until the technology of composite structures enabled the wing to be designed with skins formed from multiple layers of adhesive-bonded fibres of carbon or glass. With such skins the directions of the fibres can be arranged to give maximum strength, rather like the directions of the grain in plywood. The first successful jet FSW was the Grumman X-29, first flown in December 1984. This exerted a strong influence on the Sukhoi S-32 design team, which under Mikhail Simonov was led by First Deputy General Designer Mikhail A Pogosyan, and included Sergei Korotkov who is today's S-37 chief designer. From 1983 the FSW was exhaustively investigated, not only by aircraft OKBs but especially by CAHI (TsAGI) and the Novosibirsk-based SibNIA, which tunnel-tested several FSW models based loosely on the Su-27. By 1990 Simonov was determined to create an FSW prototype, and three years later the decision had been taken not to wait for non-existent State funds but instead to put every available Sukhoi ruble into constructing such an aircraft. Despite a continuing absence of official funding, this has proved to be possible because of income from export

S-37 Berkut





Above and below: Two views of S-37 Berkut.

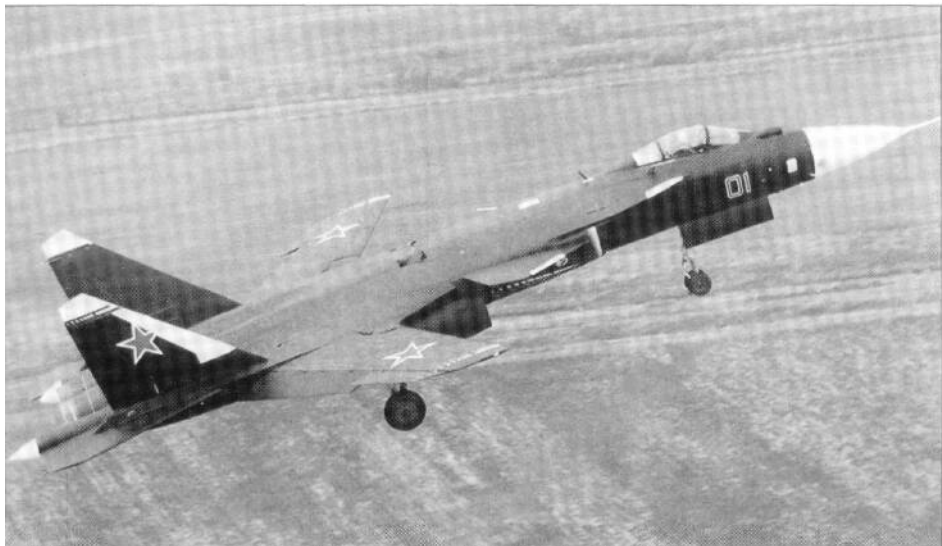
sales of fighters of the Su-27 family. Construction began in early 1996, but in that year Western aviation magazines began chanting that the S-32 was soon to fly. Uncertain about the outcome, Simonov changed the designation to S-37, so that he could proclaim 'The S-32 does not exist'. It had been hoped to fly the radical new research aircraft at the MAKS-97 airshow, but it was not ready in time. It was a near miss, because the almost completed S-37 had begun ground testing in July, and by August it was making taxi tests at LII Zhukovskii, the venue for the airshow. After MAKS 97 was over it emerged again, and on 25th September 1997 it began its flight test programme. The assigned pilot is Igor Viktorovich Votintsev. A cameraman at the LII took film which was broadcast on Russian TV, when the aircraft was publicised as the Berkut (golden eagle). On its first flight, when for a while the landing gear was retracted, the S-37 was accompanied by a chase Su-30 carrying a photographer. It is a long way from being an operational fighter, but that is no rea-

son for dismissing it as the WS, Ministry of Defence and the rival MiG company have done. Fortunately there are a few objective people in positions of authority, one being Marshal Yevgenii Shaposhnikov, former WS C-in-C. Despite rival factions both within the WS and industry (and even within OKB Sukhoi) this very important aircraft has made it to the flight-test stage. Whether it can be made to lead to a fully operational fighter is problematical.

The primary design objective of this aircraft is to investigate the aerodynamics and control systems needed to manoeuvre at angles of attack up to at least 100° . From the outset it was designed to be powered by two AL-41F augmented turbofans from Viktor Chepkin's Lyul'ka Saturn design bureau. In 1993 he confidentially briefed co-author Gunston on this outstanding engine. At that time it had already begun flight testing under a Tu-16 and on one side of a MiG-25PD (aircraft 84-20). Despite this considerable maturity it was not cleared as the sole source of propulsion in time for the S-37, though the aircraft could be re-engined later. Accordingly the Sukhoi prototype is at

present powered by two AL-31F engines, with dry and afterburning thrusts of 8,100 and 12,500kg (17,557 and 27,560 lb), respectively. Special engines were tailored to suit the S-37 installation, but at the start of the flight programme they still lacked vectoring nozzles. The engines are mounted only a short distance apart, fed by ducts from lateral inlets of the quarter-circle type. At present the inlets are of fixed geometry, with inner splitter plates standing away from the wall of the fuselage and bounded above by the underside of the very large LERX (leading-edge root extension), which in fact is quite distinct from the root of the wing. The wing itself comprises an inboard centroplan with leading-edge sweep of 70° , leading via a curved corner to the main panel with forward sweep of 24° on the leading edge and nearly 40° on the trailing edge. The forward-swept portion has a two-section droop flap over almost the whole leading edge, and plain trailing-edge flaps and outboard ailerons. Structurally it is described as '90 per cent composites'. The main wing panels are designed so that in a derived aircraft they could fold to enable the aircraft





Three views of S-37 Berkut.

to fit into the standard Russian hardened aircraft shelter. Aerodynamically the S-37 is another 'triplane', having canard foreplanes as well as powered tailplanes. The former are greater in chord than those of later Su-27 derivatives, the trailing edge being tapered instead of swept back. Likewise the tailplanes have enormous chord, but as the leading-edge angle is over 75° their span is very short. As in other Sukhoi fighters, the tailplanes are pivoted to beams extending back from the wing on the outer side of the engines. Unlike previous Sukhois the tailplanes are not mounted on spigots on the sides of the beams but on transverse hinges across their aft end. These beams also carry the fins and rudders, which are similar to those of other Sukhois apart from being further apart (a long way outboard of the engines) and canted outward. After flight testing had started the rudders were given extra strips (in Russia called knives) along the trailing edge. When the S-37 is parked, with hydraulic pressure decayed, the foreplanes, tailplanes and ailerons come to rest 30° nose-up. The landing gear is almost identical to that of the Su-27K, with twin steerable nosewheels. In the photographs released so far no airbrakes or centreline braking-parachute container can be seen. In-

ternal fuel capacity is a mere 4,000kg (8,818lb), though much more could be accommodated. The cockpit has an Su-27 type upward-hinged canopy, and a sidestick on the right. The airframe makes structural provision for 8 tonnes (17,637 lb) of external and internal weapons, including a gun in the left centroplan. It is also covered in numerous flush avionics antennas, though the only ones that are functional are those necessary for aerodynamic and control research. A bump to starboard ahead of the wraparound windscreen could later contain an opto-electronic (TV, IR, laser) sight, while the two tail beams are continued different distances to the rear to terminate in prominent white domes, doubtless for avionics though they could conceivably house braking parachutes. These domes stand out against the startling dark blue with which this aircraft has been painted. Sukhoi has stressed that this aircraft incorporates radar-absorbent and beneficially reflective 'stealth' features, though again the objective is research. Also standing out visually are the white-bordered red stars, though of course the aircraft is company-owned and bears 'OKB Sukhoi' in large yellow characters on the fuselage, along with callsign 01, which confusingly is the same as the MiG 1.44.

The Russians have traditionally had a strong aversion to what appear to be unconventional solutions, and this has in the past led to the rejection of many potentially outstanding aircraft. The S-37 has to overcome this attitude, as well as the bitter political struggle within the OKB, with RSK MiG, with factions in the Ministry of Defence and air force and, not least, two banks which are battling to control the OKB.

| Dimensions | | |
|----------------------|------------------|---------------------|
| Span | 16.7m | 54 ft 6 in |
| Length (ex PVO boom) | 22.6m | 74 ft 1 1/2 in |
| Wing area about | 67m ² | 721 ft ² |

| Weights | | |
|--------------------------------|-----------|-----------|
| Take-off mass given as | 24 tonnes | 52,910 lb |
| (the design maximum is higher) | | |

| Performance | | |
|---|-------------|----------------------|
| Design maximum speed | 1,700 km/h, | 1,057 mph (Mach 1.6) |
| (which would explain the fixed-geometry inlets. At Mach numbers much higher than this the FSW is less attractive) | | |
| At press time no other data had emerged. | | |

TsybinTs-1,LL

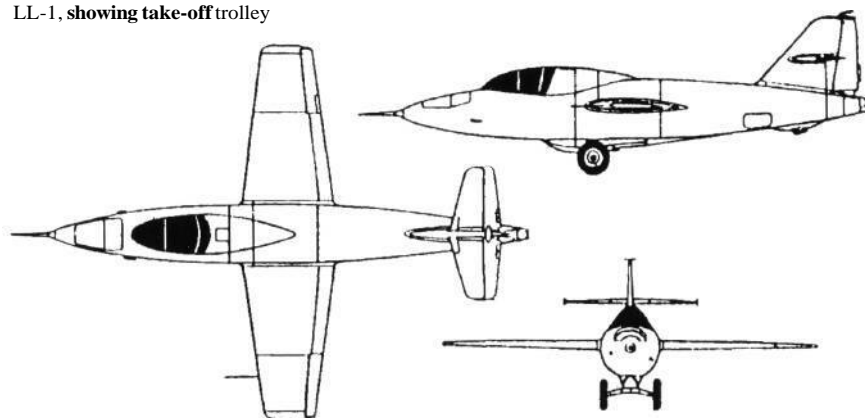
Purpose: To study wings for transonic flight.

Design Bureau: OKB-256, Chief Designer Pavel Vladimirovich Tsybin, professor at Zhukovskii academy.

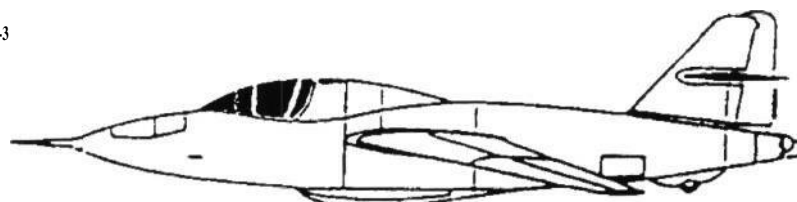
In September 1945 the LII-MAP (Flight Research Institute) asked Tsybin to investigate wings suitable for flight at high Mach numbers (if possible, up to 1). In 1946 numerous models were tested at CAHI (TsAGI), as a result of which OKB-256 constructed the Ts-1, also called LL-1 (flying laboratory 1). Almost in parallel, a design team at the OKB led by A V Beresnev developed a new fuselage and tail and two new wings, one swept back and the other swept forward. The LL-1 made 30 flights beginning in mid-1947 with NII-WS pilot M Ivanov, and continuing with Amet-Khan Sultan, S N Anokhin and N S Rybko. On each flight the aircraft was towed by a Tu-2. Casting off at 5-7km (16,400-23,000ft), the aircraft was dived at 45°-60° until at full speed it was levelled out and the rocket fired. In winter 1947-48 the second Ts-1 was fitted with the swept-forward wing to become the LL-3. This made over 100 flights, during which a speed of 1,200km/h (746mph) and Mach 0.97 were reached, without aeroelastic problems and yielding much information. The swept-back wing was retrofitted to the first aircraft to create the LL-2, but this was never flown.

The original Ts-1 (LL-1) was essentially all-wood. The original wing had two Delta (resin-bonded ply) spars, a symmetric section of 5 per cent thickness, 0° dihedral and +2° incidence. It had conventional ailerons and plain flaps (presumably worked by bottled gas pressure). Take-offs were made from a two-wheel jettisonable dolly, plus a small tail-wheel. In the rear fuselage was a PRD-1500 solid-propellant rocket developed by 11 Kartukov, giving 1,500kg (3,307lb) (more at high altitude) for eight to ten seconds. Flight controls were manual, with mass balances. On early flights no less than one tonne (2,205lb) of water was carried as ballast, simulating instrumentation to be installed later. This was jettisoned before landing, when the aircraft (now a glider) was much more manoeuvrable. Landings were made on a skid. Various kinds of instrumentation were carried, and at times at least one wing was tufted and photographed. The LL-3 was fitted with a metal wing with a forward sweep of 30° (according to drawings this was measured on the leading edge), with no less than 12° dihedral. The new tailplane had a leading-edge sweepback of 40°. To adjust the changed centres of lift and of gravity new water tanks were fitted in the nose and tail. Both LL-1 and LL-3 were considered excellent value for money.

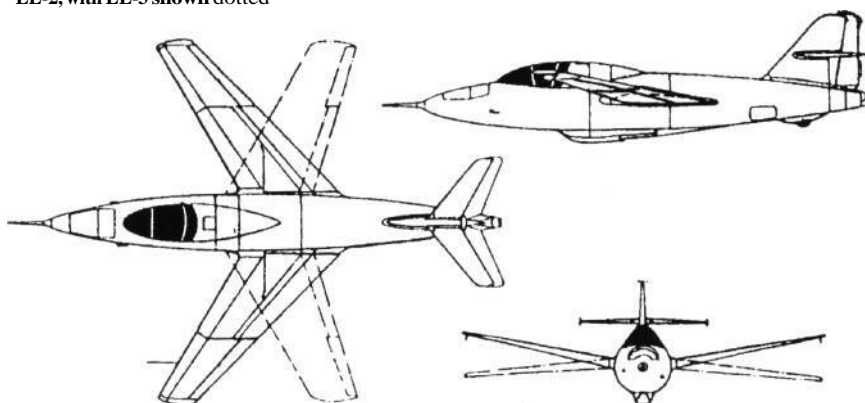
LL-1, showing take-off trolley



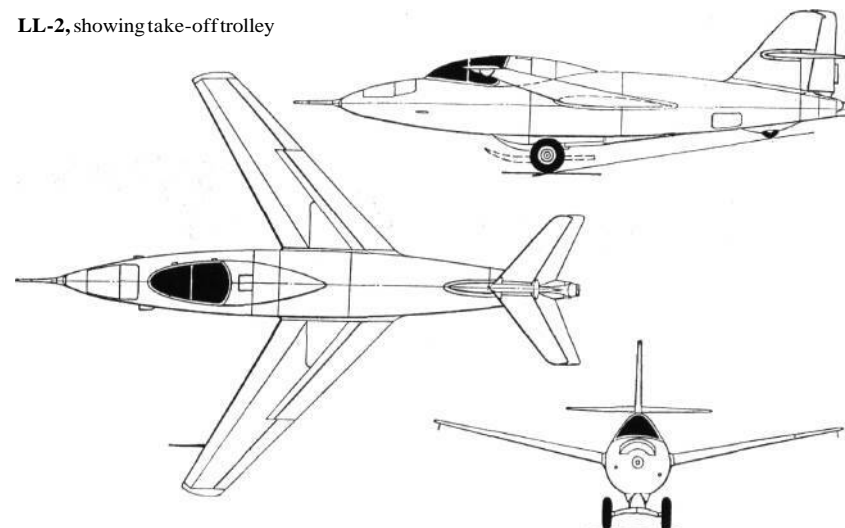
LL-3



LL-2, with LL-3 shown dotted



LL-2, showing take-off trolley



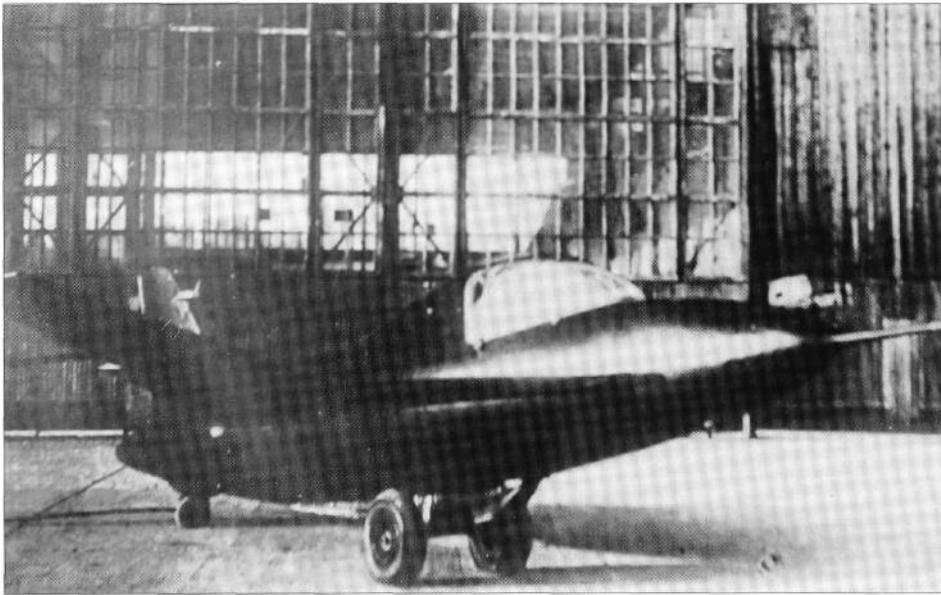


| Dimensions (LL-1) | | |
|-------------------|---------------------|---------------------------|
| Span | 7.1 m | 23 ft 3 [⁄] 4 in |
| Length | 8.98 m | 29 ft 5 1/4 in |
| Wing area | 10.0 m ² | 108 ft ² |
| Weights | | |
| Empty | 1 tonne | 2,205 lb |
| Loaded | 2,039 kg | 4,495 lb |
| Landing | 1,100 kg | 2,425 lb |
| Performance | | |
| Max speed reached | 1,050 km/h | 652 mph |
| Landing speed | 120 km/h | 74.6 mph |

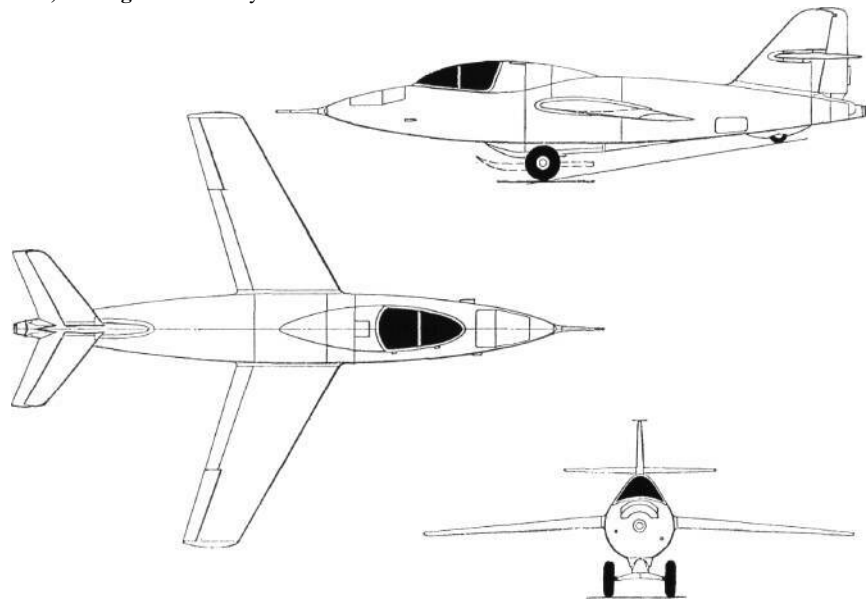
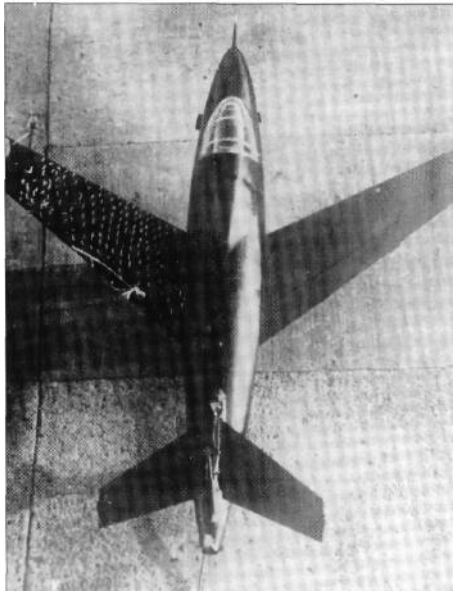
Left: LL-1.

Below left: LL-2.

Below: LL-2, left wing tufted.



LL-3, showing take-off trolley



| Dimensions (LL-3) | | |
|-------------------|---------------------|---------------------|
| Span | 7.22 m | 23 ft 8 1/4 in |
| Length | 8.98 m | 29 ft 5 1/4 in |
| Wing area | 10.0 m ² | 108 ft ² |
| Weights | | |
| Loaded | 2,039 kg | 4,495 lb |
| Landing | 1,100 kg | 2,425 lb |
| Performance | | |
| Max speed reached | 1,200 km/h | 746 mph |
| Landing speed | 120 km/h | 74.6 mph |

Tsybin RS

Purpose: To create a winged strategic delivery vehicle.

Design Bureau: OKB-256, Podberez'ye, Director P V Tsybin.

In the early 1950s it was evident that the forthcoming thermonuclear weapons would need strategic delivery systems of a new kind. Until the ICBM (intercontinental ballistic missile) was perfected the only answer appeared to be a supersonic bomber. After much planning, Tsybin went to the Kremlin on 4th March 1954 and outlined his proposal for a Reaktivnyi Samolyot (jet aeroplane). The detailed and costed Preliminary Project was issued on 31st January 1956, with a supplementary submission of a reconnaissance version called 2RS. Korolyov's rapid progress with the R-7 ICBM (launched 15th May 1957 and flown to its design range on 21st August 1957) caused the RS to be abandoned. All effort was transferred to the 2RS reconnaissance aircraft (described next).

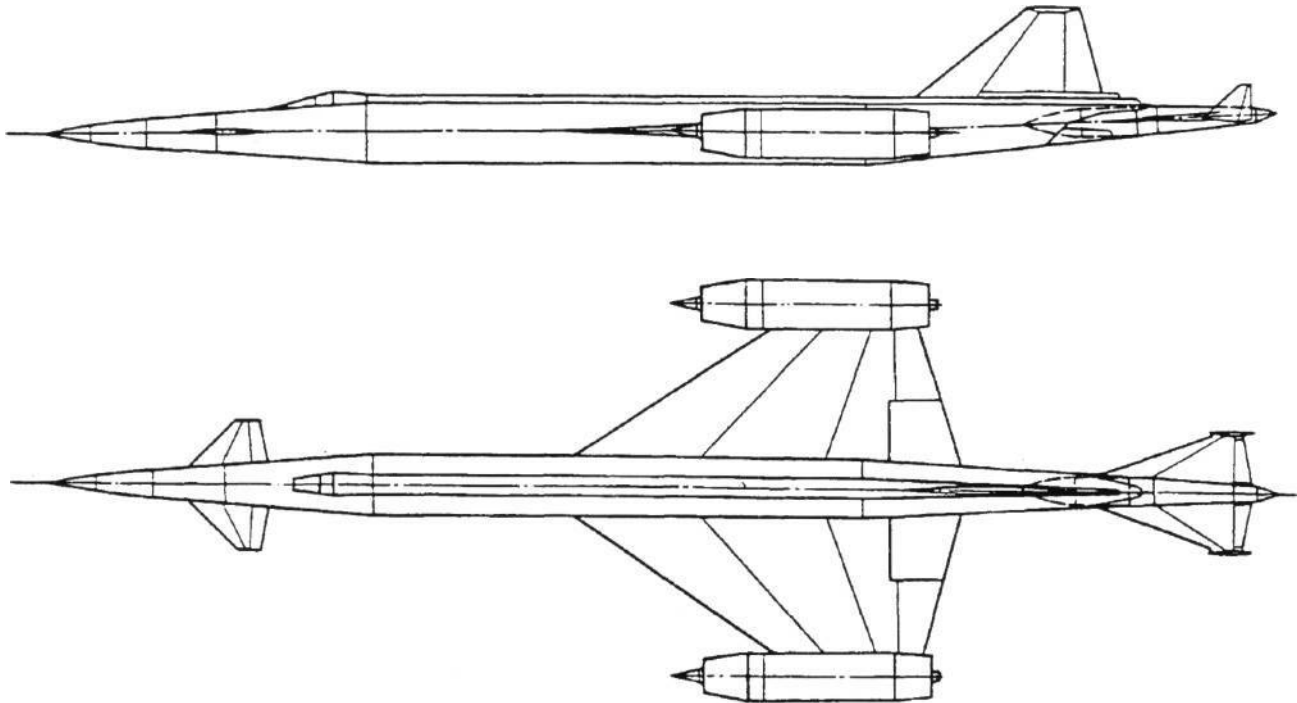
The RS had an aerodynamically brilliant configuration, precisely repeated in the British Avro 730 which was timed over a year later. The wing was placed well back on the long circular-section fuselage and had a symmetric section with a thickness/chord ratio of 2.5 to 3.5 per cent. It had extremely low aspect ratio (0.94) and was sharply tapered on both edges. Large-chord flaps were provided inboard of conventional ailerons, other flight

controls comprising canard foreplanes and a rudder, all surfaces being fully powered. The cockpit housed a pilot in a pressure suit, seated in an ejection-seat under a canopy linked to the tail by a spine housing pipes and controls. The RS was to be carried to a height of 9km (29,528ft) under a Tu-95N. After release it was to accelerate to supersonic speed (design figure 3,000km/h) on the thrust of two jet-tisoned rocket motors. The pilot was then to start the two propulsion engines, mounted on the wingtips. These were RD-013 ramjets, designed by Bondaryuk's team at OKB-670. Each had a fixed-geometry multi-shock inlet and convergent/divergent nozzle matched to the cruise Mach number of 2.8. Internal diameter and length were respectively 650mm (2ft 1Hin) and 5.5m (18ft 1/2in). The 1955 project had 16.5 tonnes of fuel, or nearly 3.5 times the 4.8-t empty weight, but by 1956 the latter had grown and fuel weight had in consequence been reduced. The military load was to be a 244N thermonuclear bomb weighing 1,100kg (2,425lb). The only surviving drawing shows this carried by a tailless-delta missile towed to the target area attached behind the RS fuselage (see below). Data for this vehicle are not known.

Outstandingly advanced for its day, had this vehicle been carried through resolutely it would have presented 'The West' with a serious defence problem.

| | | |
|--|-------------------|--------------------|
| Dimensions | | |
| Span (over engine centrelines) | 9.0 m | 29 ft 6 in |
| Basic wing | 7.77 m | 25ft5 3/4in |
| Foreplane | 3.2 m | 10 ft 6 in |
| Length | 27.5 m | 90 ft 2 in |
| Wing area | 64 m ² | 689ft ² |
| Weights | | |
| Empty | 5,200 kg | 11,464lb |
| Fuel | 10,470kg | 23,082 lb |
| Maximum take-off weight | 21,160 kg | 46,649 lb |
| Performance | | |
| Range at 3,000 km/h (1,864 mph, Mach 2.82) | | |
| at 28 km (91,864 ft) altitude | 13,500 km | 8,389 miles |
| Landing speed/ | 245 km/h | 152 mph |
| run | 1,100m | 3,610ft |

RS



Tsybin2RS

Purpose: To create a strategic reconnaissance aircraft.
Design Bureau: OKB-256, Podberez'ye, Director P V Tsybin.

As noted previously, the 2RS was launched as a project in January 1956. It was to be a minimum-change derivative of the RS, carried to high altitude under the Tu-95N and subsequently powered by two RD-013 ramjets. However, it was decided that such an aircraft would be operationally cumbersome and inflexible, and that, despite a very substantial reduction in operational radius, it would be preferable to switch to conventional afterburning turbojets and take off from the ground. The revised project was called RSR (described later). The Ministry gave this the go-ahead on 31st August 1956, but work on

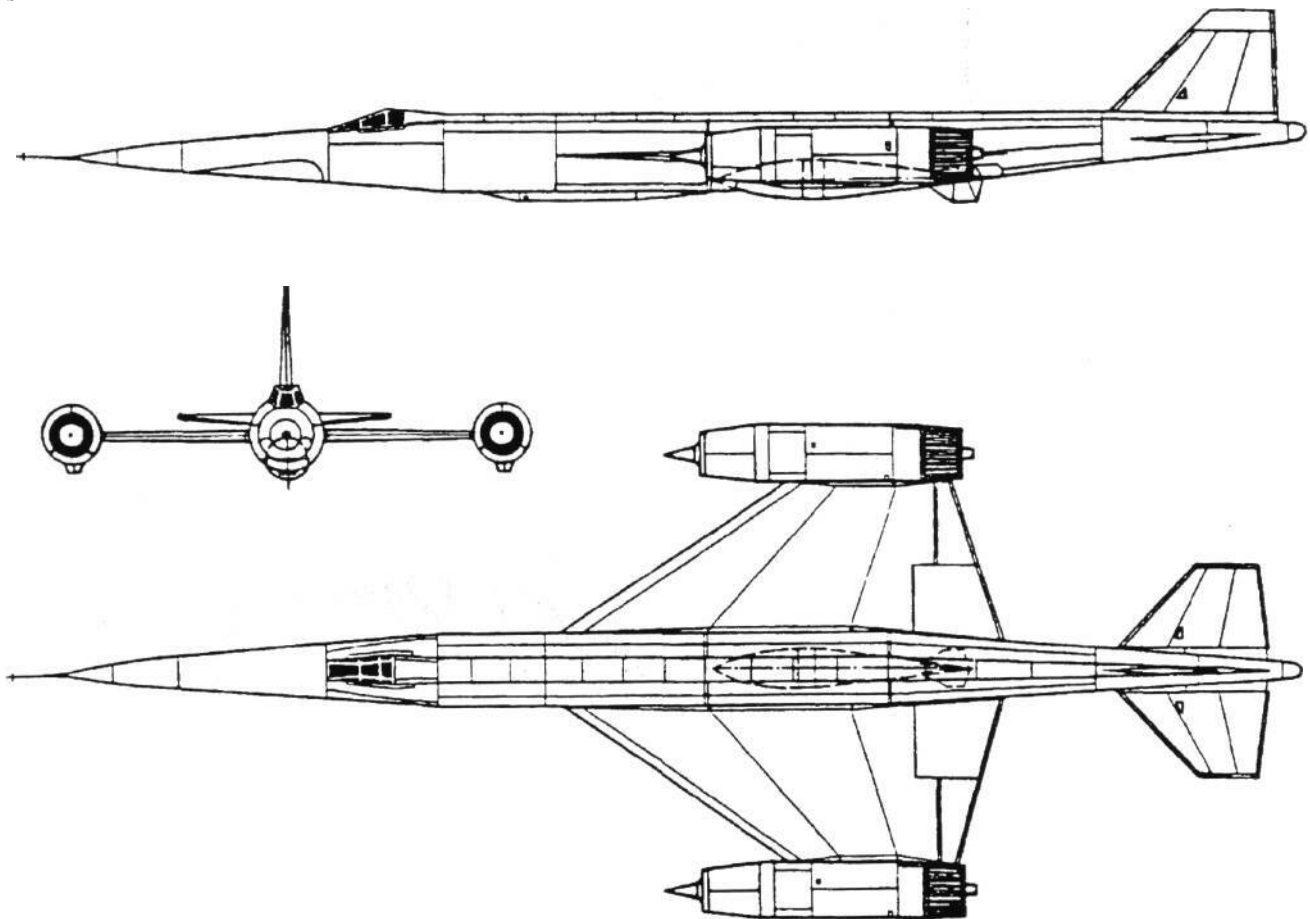
the 2RS continued until it was terminated in early 1957. As it was no longer needed, Tupolev then stopped the rebuild of the Tu-95N carrier at Factory No 18 at Kuibyshev.

The 2RS would have differed from the RS principally in having the canard foreplanes replaced by slab tailplanes. Behind these was installed a braking parachute. Provision was made for large reconnaissance cameras in the fuselage ahead of the wing. Surviving drawings (below) also show provision for a 244N thermonuclear weapon, this time as a free-fall bomb recessed under the fuselage further aft. Carrying this would have moved the main landing gear unacceptably close to the tail.

Though there was much to be said for air launch, the basic concept looked increasingly unattractive.

| | | |
|--|---------------------|-----------------------|
| Dimensions | | |
| Span (over engine centrelines) | 9.0 m | 29 ft 6 in |
| Length | 27.4 m | 89 ft 1 1/2 in |
| Wing area | 64.0 m ² | 689 ft ² |
| Weight | | |
| Empty | 9,030 kg | 19,907 lb |
| Fuel | 11,800 kg | 26,014 lb |
| Loaded (cameras only) | 20,950 kg | 46,186 lb |
| Performance | | |
| Max (also cruising) speed at 20 km (65,617 ft) | 2,700 km/h | 1,678 mph (Mach 2.54) |
| Service ceiling | 27 km | 88,583 ft |
| Range (high altitude) | 7,000 km | 4,350 miles |
| Landing speed/run | 230 km/h 800 m | 143 mph 2,625 ft |

2RS



Tsybin RSR

Purpose: To create an improved reconnaissance aircraft.

Design Bureau: OKB-256, Podberez'ye, Director P V Tsybin.

The preliminary project for the revised aircraft, able to take off in the conventional manner, was dated 26th June 1957. Design proceeded rapidly, and in parallel OKB-256 created a simplified version, using well-tryed engines, which could be got into the air quickly to provide data (see NM-1, next). These data became available from April 1959, and resulted in significant changes to the RSR (see R-020). The basic design, however, can be described here.

Though the RSR was derived directly from the 2RS, it differed in having augmented bypass turbojet engines (low-ratio turbofans) and strengthened landing gear for conventional full-load take-offs. A basic design choice was to make the structure as light as possible by selecting a design load factor of only 2.5 and avoiding thermal distortion despite local skin temperatures of up to 220°C. By this means the use of steel and titanium was almost eliminat-

ed, though some skins (ailerons, outer wing and tail torsion boxes) were to be in aluminium/beryllium alloy. As before, the wing had a t/c ratio of 2.5 per cent, 58° leading-edge sweep and three main and two secondary spars. The tips, 86mm deep, carried Solov'yov D-21 bypass engines. These bore no direct relationship to today's D-21A1 by the same design team. They were two-shaft engines with a bypass ratio of 0.6, and in cruising flight they were almost ramjets. Sea-level dry and augmented ratings were 2,200kg (4,850 lb) and 4,750kg (10,472 lb) respectively. Dry engine mass was 900kg (1,984 lb) and nacelle diameter was 1.23m (4ft 1/2in). The fuselage had a fineness ratio of no less than 18.6, diameter being only 1.5m (4ft 1 lin). All tail surfaces had a t/c ratio of 3.5 per cent, and comprised a one-piece vertical fin with actuation limits of $\pm 18^\circ$ and one-piece tailplanes with limits of $+ 10^\circ/-25^\circ$. All flight controls were fully powered, with rigid rod linkages from the cockpit and an artificial-feel system. The main and steerable nose landing gears now had twin wheels, and were supplemented by single-

wheel gears under the engines, all four units hydraulically retracting to the rear. A braking parachute was housed in the tailcone. A total of 7,600kg (16,755 lb) of kerosene fuel was housed in integral tanks behind the cockpit and behind the wing, plus 4,400kg (9,700 lb) in two slender (650mm, 2ft 1 V-in diameter) drop tanks. An automatic trim control system pumped fuel to maintain the centre of gravity at 25 per cent on take-off, 45.0 in cruising flight and 26.4 on landing. In cruising flight the cockpit was kept at 460mm Hg, and the pilot's pressure suit maintained 156mm after ejection. An APU and propane burner heated the instrument and camera pallets which filled the centre fuselage, a typical load comprising two AFA-200 cameras (200mm focal length) plus an AFA-1000 or AFA-1800 (drawings show four cameras), while other equipment included optical sights, panoramic radar, an autopilot, astro-inertial navigation plus a vertical gyro, a radar-warning receiver and both active and passive ECM (electronic countermeasures)

During construction this aircraft was modified into the RSR R-020.

Dimensions

| | | |
|------------------------------|---------------------|--------------------------------------|
| Span (over engines) | 10.23 m | 33ft6 ³ / ₄ in |
| (ignoring engines) | 7.77 m | 25ft5 ³ / ₄ in |
| Length (ignoring nose probe) | 27.4 m | 89 ft 10% in |
| Wing area | 64.0 m ² | 689ft ² |

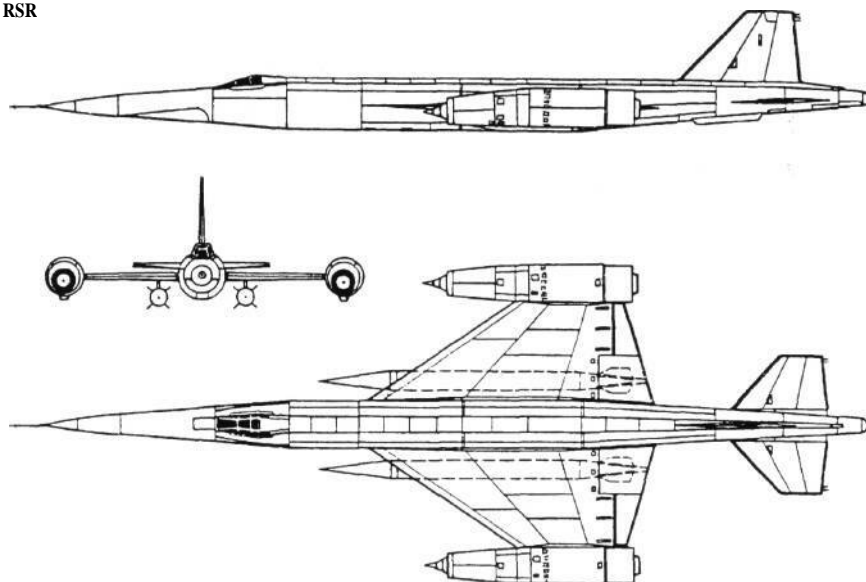
Weights

| | | |
|--------|-----------|-----------|
| Empty | 8,800 kg | 19,400 lb |
| Fuel | 12 tonnes | 26,455 lb |
| Loaded | 21 tonnes | 46,296 lb |

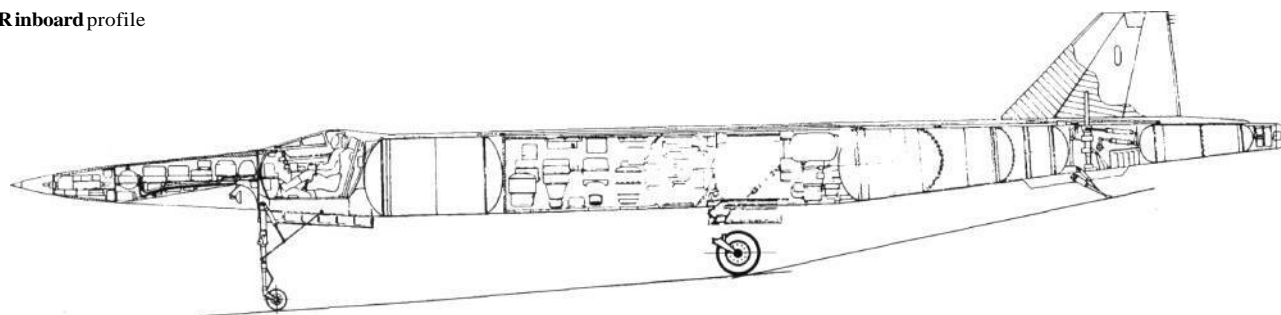
Performance

| | | |
|---------------------------|------------|-----------------------|
| Cruising speed | 2,800 km/h | 1,740 mph (Mach 2.64) |
| at service ceiling of | 26,700 m | 87,600ft |
| Range | 3,760 km | 2,336 miles |
| Take-off | 1,300m | 4,265 ft |
| Landing speed/run | 245 km/h | 152 mph |
| (using braking parachute) | 1,200 m | 3,937ft |

RSR



RSR inboard profile



TsybinNM-1

Purpose: To provide full-scale flight data to support the RSR.

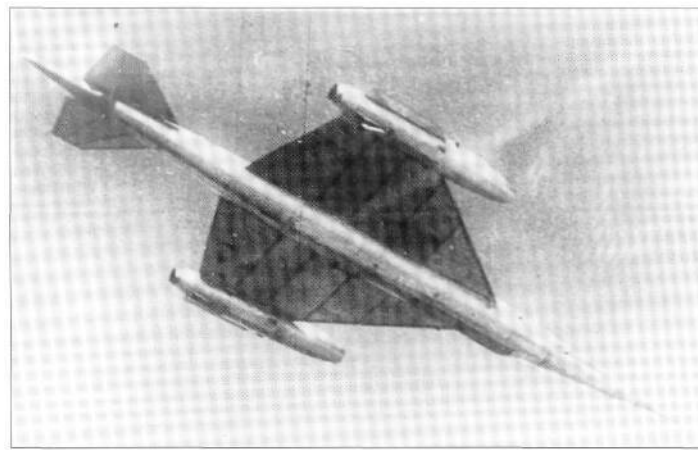
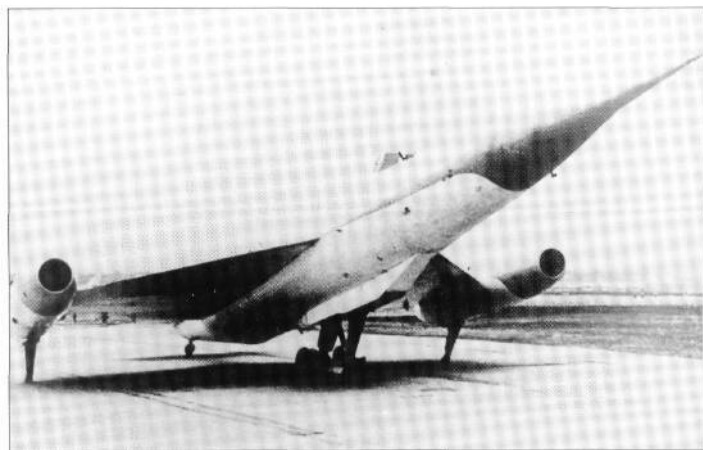
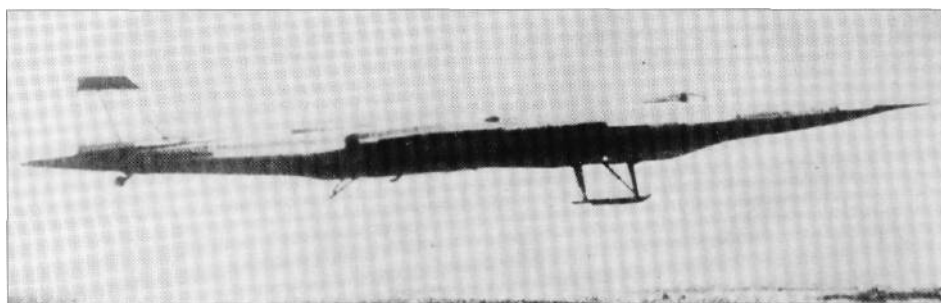
Design Bureau: OKB-256, Podbez'yev, Director P V Tsybin.

In autumn 1956 funding was provided for a research aircraft designated NM-1 (Natrnyaya Model', life [like] model). This was to be a single flight article with an airframe based upon that of the RSR but simplified, with proven engines and stressed for lighter weights. It was completed in September 1958. On 1st October Amet-Khan Sultan began taxi testing, and he made the first flight on 7th April 1959, with a Yak-25 flying chase. The flight plan called for

take-off at 220km/h, but after a tentative hop Sultan actually took off at 325km/h, and jettisoned the dolly at 40m (131ft) at 400km/h (248mph). The dolly broke on hitting the runway (on later flights it had an automatic parachute). Sultan easily corrected a slight rolling motion, and flew a circuit at 1,500m at 500km/h before making a landing at 275km/h (90km/h faster than planned). Altogether Sultan and Radii Zakharov made 32 flights, establishing generally excellent flying qualities (take-off, approach and landing 'easier than MiG or Su aircraft') but confirming neutral or negative stability in roll.

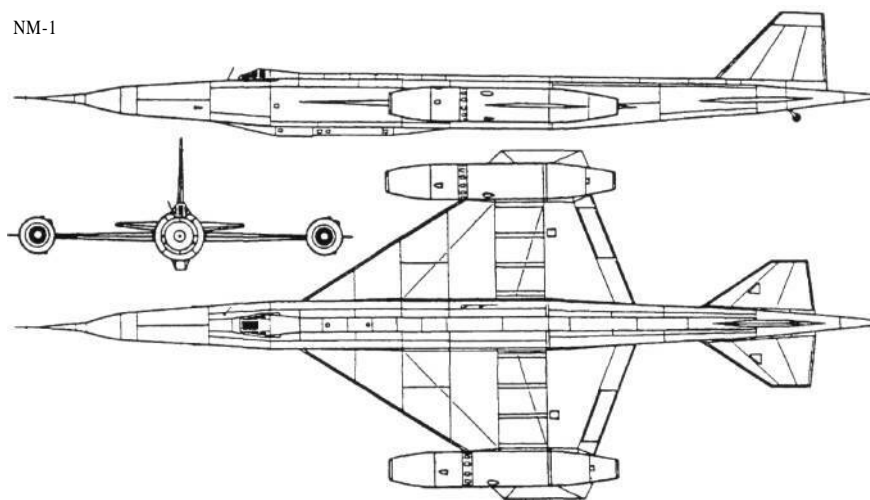
The five-spar 2.5-per-cent wing had constant-chord ailerons and flaps which were unlike those of the RSR. On the tips were two Mikulin (Tumanskii) AM-5 turbojets each rated at 2,000kg (4,409 lb) thrust, in simple nacelles without inlet centrebodies. The pilot sat in an ejection-seat under a very small canopy; the low-drag RS-4/01 canopy, resembling that of the RSR, was never fitted. Along the centreline were a sprung skid, hydraulically retracted into a long box, and a small tailwheel, while hydraulically extended skids were hinged under the nacelles. For take-offs a jettisonable two-wheel dolly was attached under the main skid. A door under the pointed tailcone released the braking parachute. After the taxi tests, following recommendations from CAHI (TsAGI) small extra wing surfaces were added outboard of the engines. The fuselage contained two kerosene tanks, a hydraulic-fluid tank and a nose water tank to adjust centre of gravity to 25.5 per cent of mean aerodynamic chord.

The NM-1 showed that the basic RSR concept was satisfactory.



Above: Three views of NM-1.

NM-1



| Dimensions | | |
|-----------------------------------|-------------------|---------------------|
| Span (between engine centrelines) | 8.6 m | 28 ft 7 in |
| (overall) | 10.48 m | 34 ft 4.5 in |
| Length | 26.57 m | 87 ft 7 in |
| Wing area | 64 m ² | 689 ft ² |
| Weights | | |
| Empty | 7,850 kg | 17,306 lb |
| Fuel | 1,200 kg | 2,646 lb |
| Loaded | 9,200 kg | 20,282 lb |
| Performance | | |
| Max speed (achieved) | 500 km/h | 311 mph |
| High performance not explored | | |
| Take-off run | 1,325 m | 4,347 ft |
| Landing run from | 275 km/h | 171 mph |
| | 1,180 m | 3,871 ft |

Tsybin RSR, R-020

Purpose: To improve the RSR further.

Design Bureau: OKB-256, Podberez'ye, later repeatedly transferred (see below).

Upon receipt of data from the NM-1, the RSR had to be largely redesigned. Construction was only marginally held up, and in early 1959 drawings for the first five pre-series R-020 aircraft were issued to Factory No 99 at Ulan-Ude. However, Tsybin's impressive aircraft had their commercial rivals and political enemies, some of whom just thought them too 'far out', and in any case vast sums were being transferred to missiles and space. On 1st October 1959 President Khrushcheyev closed OKB-256, and the Ministry transferred the RSR programme to OKB-23 (General Constructor VM Myasishchev) at the vast Khrunichev works. The Podberez'ye facilities were taken over by A Ya Berezhnyak (see BI story). The Khrunichev management carried out a feasibility study for construction of the R-020, but in October 1960 Myasishchev was appointed Director of CAHI (TsAGI). OKB-23 was closed, and the entire Khrunichev facility was assigned to giant space launchers. The RSR programme was thereupon again moved, this time to OKB-52. At first this organization's General Constructor V N Chelomey supported Tsybin's work, but increasingly it interfered with OKB-52's main programmes. In April 1961, despite the difficulties, the five R-020 pre-series aircraft were essentially complete, waiting only for engines. In that month came an order to terminate the programme and scrap the five aircraft. The workforce bravely refused, pointing out how much had been accomplished and how near the aircraft were to being flown. The management quietly put them into storage (according to

V Pazhitnyi, the Tsybin team were told this was 'for eventual further use'). Four years later, when the team had dispersed, the aircraft were removed to a scrapyard, though some parts were taken to the exhibition hall at the Moscow Aviation Institute.

The airframe of the 1960 RSR differed in several ways from the 1957 version. To avoid surface-to-air missiles it was restressed to enable the aircraft to make a barrel roll to 42km (137,800ft). The wings were redesigned with eight instead of five major forged and machined ribs between the root and the engine. The leading edge was fitted with flaps, with maximum droop of 10°. The trailing edge was tapered more sharply, and area was maintained by adding a short section (virtually a strake) outboard of the engine. These extensions had a sharp-edged trapezoidal profile. According to Tsybin 'These extensions, added on the recommendation of CAHI, did not produce the desired effect and were omitted', but they are shown in drawings. In fact, CAHI really wanted a total rethink of the wing, as related in the final Tsybin entry. The tailplane was redesigned with only 65 per cent as much area, with sharp taper and a span of only 3.8m (12ft 5in). Its power unit was relocated ahead of the pivot, requiring No 6 (trim) tank to be moved forward and shortened. The fin was likewise greatly reduced in height and given sharper taper, and pivoted two frames further aft. The ventral strake underfin was replaced by an external ventral trimming fuel pipe. The main landing gear was redesigned as a four-wheel bogie with 750 x 250mm tyres, and the outrigger gears were replaced by hydraulically extended skids in case a nacelle should touch the ground. The pilot was given a better view,

with a deeper canopy and a sharp V (instead of flat) windscreen. The camera bay was redesigned with a flat bottom with sliding doors. The nose was given an angle-of-attack sensor, and a pitot probe was added ahead of the fin. The drop tanks were increased in diameter to 700mm (2ft 3 1/2in) but reduced in length to 5.8m (19ft) instead of 11.4m (37ft 4in). Not least, the D-21 engines never became available, and had to be replaced by plain afterburning turbojets. The choice fell on the mass-produced Tuman-skii R-11F, each rated at 3,940kg (8,686lb) dry and 5,750kg (12,676lb) with afterburner. These were installed in longer and slimmer nacelles, with inlet sliding centrebodies pointing straight ahead instead of angled downwards.

There is no reason to doubt that the pre-series RSR, designated R-020, would have performed as advertised. It suffered from a Kremlin captivated by ICBMs and space, which took so much money that important aircraft programmes were abandoned. The United Kingdom similarly abandoned the Avro 730, a reconnaissance bomber using identical technology, but in this case it was for the insane reason that missiles would somehow actually replace aircraft. Only the USA had the vision and resources to create an aircraft in this class, and by setting their sights even higher the Lockheed SR-71 proved valuable for 45 years.

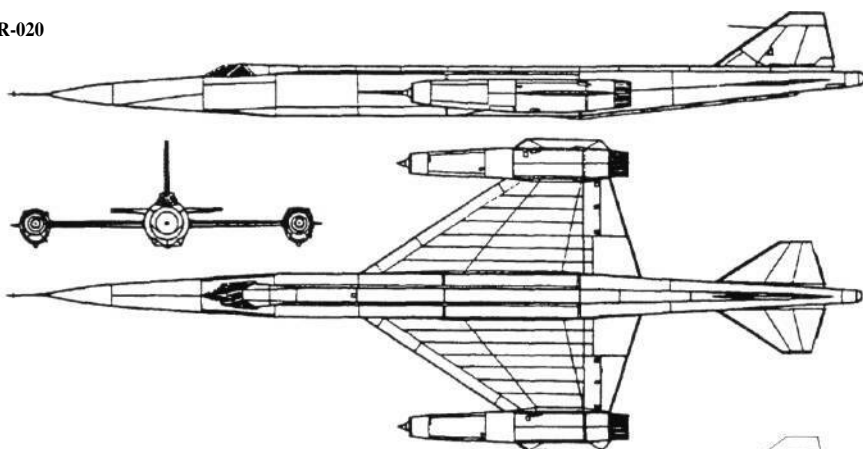
| Dimensions | | |
|----------------------------------|-------------------|---------------------|
| Span (with small tip extensions) | 10.66 m | 34 ft 1 1/2 in |
| Length (excl nose probe) | 28.0 m | 91 ft 10 in |
| Wing area | 64 m ² | 689 ft ² |
| Weights | | |
| Empty | 9,100kg | 20,062 lb |
| Fuel | 10,700kg | 23,589 lb |
| Loaded | 19,870kg | 43,805 lb |

| Performance | | |
|---|------------|-----------------------|
| Cruising speed at reduced altitude of 12 km (39,370 ft) | 2,600 km/h | 1,616 mph (Mach 2.44) |
| Service ceiling | 22,500 m | 73,819 ft |
| Range | 4,000 km | 2,486 miles take-off |
| Take-off run | 1,200m | 3,937 ft |
| Landing speed/run (with braking parachute) | 210 km/h | 130.5 mph |
| | 800 m | 2,625 ft |

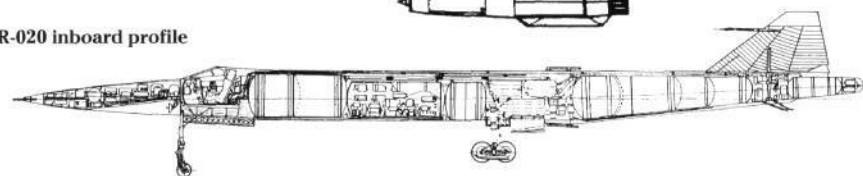
R-020 centre fuselage at MAI.



R-020

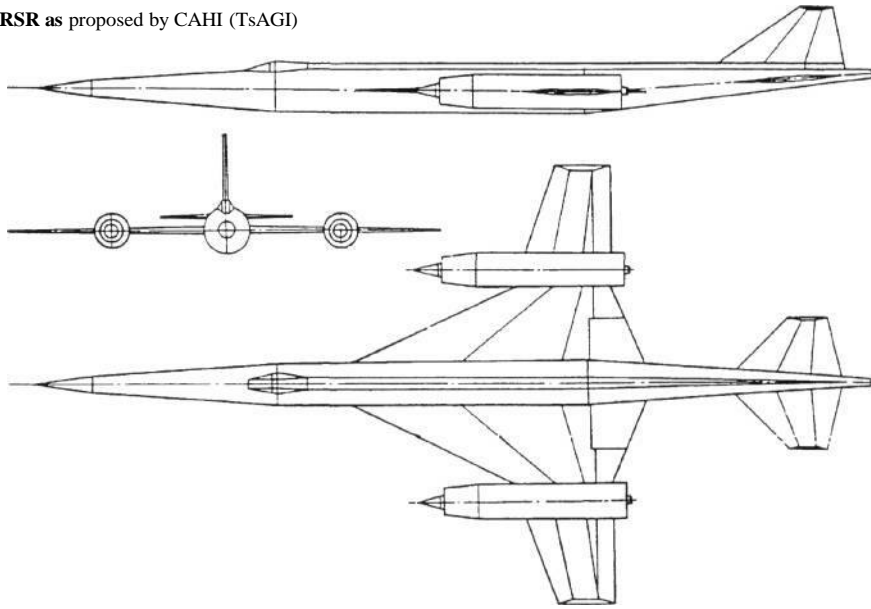


R-020 inboard profile

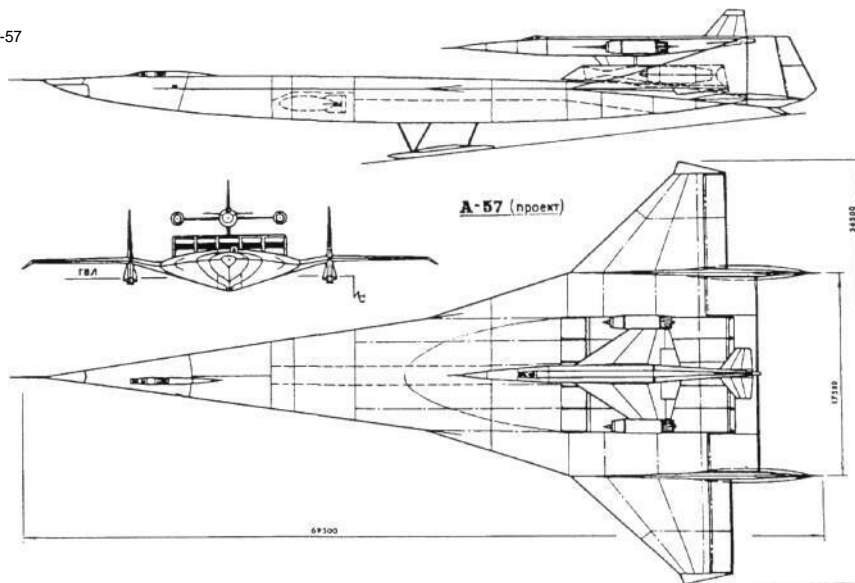


Tsybin **RSR** Derivatives

RSR as proposed by CAHI (TsAGI)

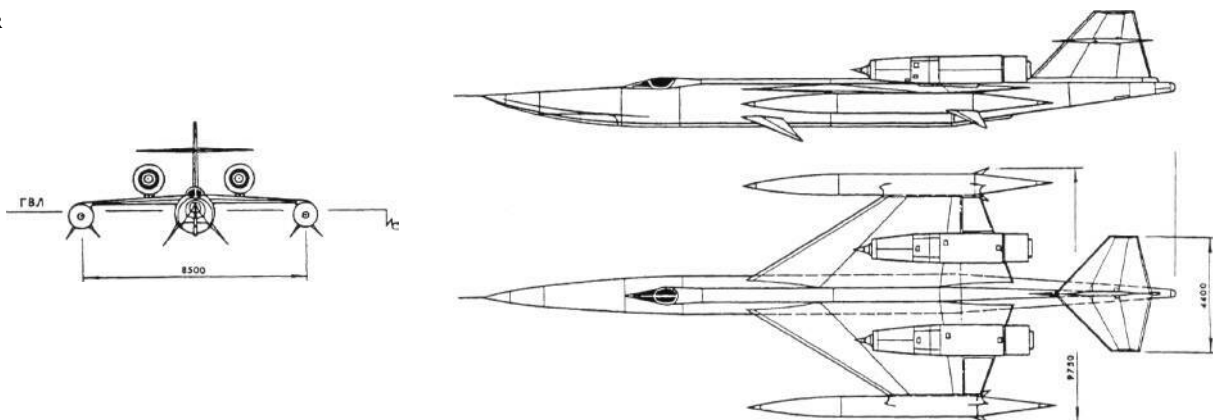


A-57



A-57 (проект)

RGSR



For interest, drawings are reproduced here of various projects which stemmed from the RSR. The first shows the way CAHI (TsAGI) wanted it. The purist aerodynamicists in that establishment were convinced that this supersonic-cruise aircraft ought to have true supersonic wings, with sharp edges and a trapezoidal (parallel double wedge) profile instead of a traditional curved aerofoil. As this would have meant a very long take-off run they proposed to add substantial wings outboard of the engines, giving a span of 14.5m (47ft 6in), requiring total redesign and a dramatically inferior aircraft. The next drawing shows the awesome A-57, proposed in 1957 by R L Bartini, who featured on previous pages. There were several versions of this and the considerably smaller Ye-57. The A-57 shown would have been powered by five Kuznetsov NK-10 engines, each of 25,000kg (55,115 lb) thrust. This 320 tonne (705,467 lb) vehicle, with a length of 69.5m (228ft) and wing area of 755m² (8,127ft²), was to have been water-based for operational flexibility and to avoid having to use vulnerable airfields (though it also had skids for airfield landings if necessary). It would have carried a 244N thermonuclear bomb internally, as well as a 2RS (later RSR) carried pick-a-back to the target at 2,500km/h (1,553mph, Mach 2.35) to serve as an accompanying reconnaissance aircraft. Together they could cover targets within a radius of 5,000km (3,107 miles), the Tsybin 2RS reconnaissance vehicle using its fuel only on the return flight. The final drawing shows the Tsybin RGSP, also dating from 1957. This too would have been water-based, with a planing bottom, engines moved above the wings to avoid the spray (minimised by the down-angled water fins), and with the external tanks serving as wingtip buoyancy bodies. This version was not equipped for airfield landings.

Tupolev ANT23, I-12

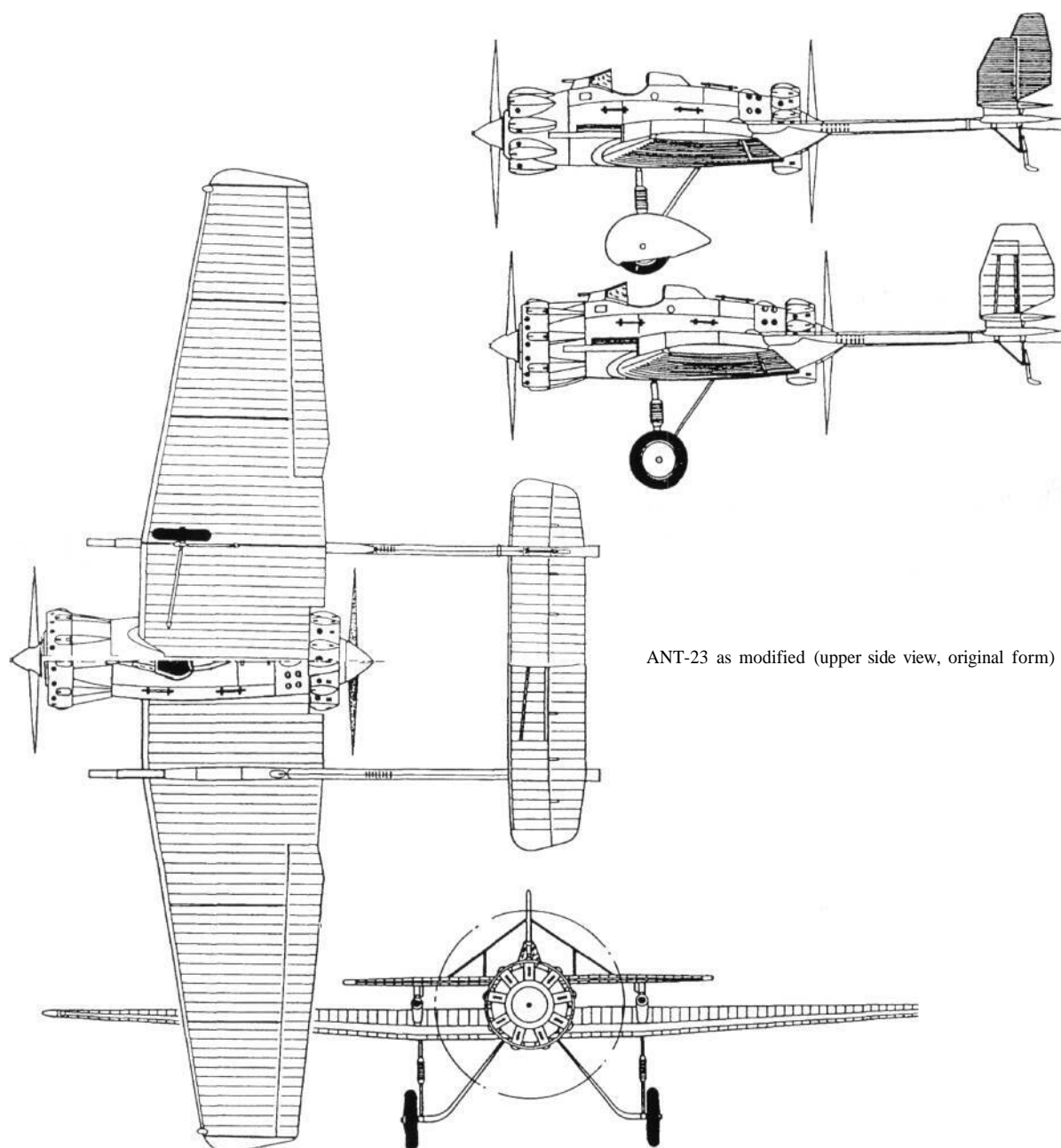
Purpose: To build an improved fighter armed with APK-4 guns.

Design Bureau: Brigade led by Viktor Nikolayevich Chernyshov in AGOS (Department of Aeroplane and Hydroplane Construction), whose Chief Constructor was AN Tupolev.

Towards the end of the 1930s there was great activity in the still chaotic aircraft industry of the embryonic Soviet Union. Part of this effort was concerned with making use of the large-calibre recoilless guns devised by LV Kurchevskii. These had various designations

but the most common was APK (Avtomaticheskaya Pushka Kurchevskogo, automatic cannon Kurchevskii). Such guns were invented by Cdr Cleland Davis, of the US Navy, and developed in England from 1915. The idea was that, if the recoil of the projectile could be balanced by a blast of gas and possibly an inert mass fired to the rear, then aircraft could use lightly made weapons of large calibres. Russian copies were produced by Professor B S Stechkin in 1922-26, and in 1930 Leonid Vasil'yevich Kurchevskii restarted this work and developed a range of weapons of different calibres. Of these the most immedi-

ately important was the APK-4, with a calibre of 76.2mm (Sin). Together with the Grigorovich Z (later I-Z) described earlier, the ANT-23 was the first aircraft specially designed to use these guns. The AGOS designers had the idea that, instead of just hanging the guns under the wings, they could be put inside strong tubes which could then attach the tail to the wing. This enabled the central nacelle to have an engine at each end, giving outstanding flight performance. Design began in June 1930, and the first flight was made by Ivan Frolovich Kozlov on 29th August 1931. On 21st March 1932 he was



ANT-23 as modified (upper side view, original form)

undertaking firing trials at about 1,000m (3,280ft) when the diffuser section at the rear of the left gun exploded. This severed the tail controls in that boom, but he managed to make a normal landing, the boom collapsing during the landing run (he received the Order of the Red Star). The fault was soon corrected, and from autumn 1931 a second prototype (called a doobler), the ANT-236/s, was built. This received service designation I-12, and was also named Baumanskii Komsomollets after the revolutionary who until his death in 1905 had worked next to the AGOS site. It incorporated various minor improvements, one of which was to arrange for the pilot in emergency to detonate a charge which severed the drive shaft to the rear propeller prior to baling out. Work was halted during the investigation into the accident to the first aircraft, and by 1933 the I-12 was overtaken by the Grigorovich IP family and the DIP, ANT-29. Work on it was stopped on 1st January 1934.

Structurally the ANT-23 followed Tupolev tradition in that it was a cantilever monoplane made entirely of aluminium alloy, but it broke new ground in that corrugated sheet was not used except on the fin and rudder. Instead, the central nacelle had smooth skin, and the wings were skinned in sheets cut to a uniform

width of 150mm (Gin), wrapped round the leading edge. The edge of each strip was rolled to have a channel section, so that the complete wing appeared to have a skin with widely spaced corrugations. In usual Tupolev fashion, the aileron chord extended behind the trailing edge of the wing. The nacelle was welded from KhMA steel tube, with much of the light-alloy skin being in the form of detachable panels. At each end was an imported 480hp Gnome-Rhone GR9K (licence-built Bristol Jupiter) in a cowl with helmets over the cylinders. Above each wing was attached a precision-made tube of high-strength steel formed by screwing together three sections each machined to an internal diameter of 170mm (6 $\frac{1}{2}$ in). Wall thickness varied from 1 to 3mm. Over the wing the tube was faired in by thin aluminium sheet, and at the tail end was a gas diffuser. Above this was a shallow platform to which was attached the tailplane, carrying the strut-braced fin in the centre. Tall sprung tailskids were attached under each tube, and originally the rubber-sprung main landing gears had spats, though these were later omitted. Inside each tail boom was installed the 76.2mm APK-4, with the front of the barrel projecting. Soon the engines were replaced by the 570hp version made under

licence in the Soviet Union as the M-22, and the helmets were incorporated into ring cowls. Another modification was to replace the vertical tail by a redesigned structure with the same kind of skin as the rest of the aircraft.

When work began it was thought that this aircraft might be a world-beater. It was soon evident that the performance was well short of expectations, partly because of the fact that the rear propeller worked in the slipstream of that in front. Perhaps the greatest shortcoming of this aircraft was the fact that the ammunition supply for each gun was limited to two rounds.



| Dimensions | | |
|-------------------------------|---------------------|---------------------|
| Span | 15.67m | 51 ft 5 in |
| Length | 9.52m | 31 ft 2 in |
| Wing area | 33.0 m ² | 355 ft ² |
| Weights | | |
| Empty | 1,818kg | 4,008 lb |
| Loaded | 2,405 kg | 5,302 lb |
| Performance | | |
| Max speed at 5 km (16,400 ft) | 318 km/h | 198 mph |
| Time to climb to 5 km | 7.7 min | (16,400ft) |
| Service ceiling | 9,320 m | 30,580ft |
| Range | 405km | 252 miles |
| Landing speed | 100knVh | 62 mph |

Two views of ANT-23 after modification.

Tupolev ANT-29, DIP

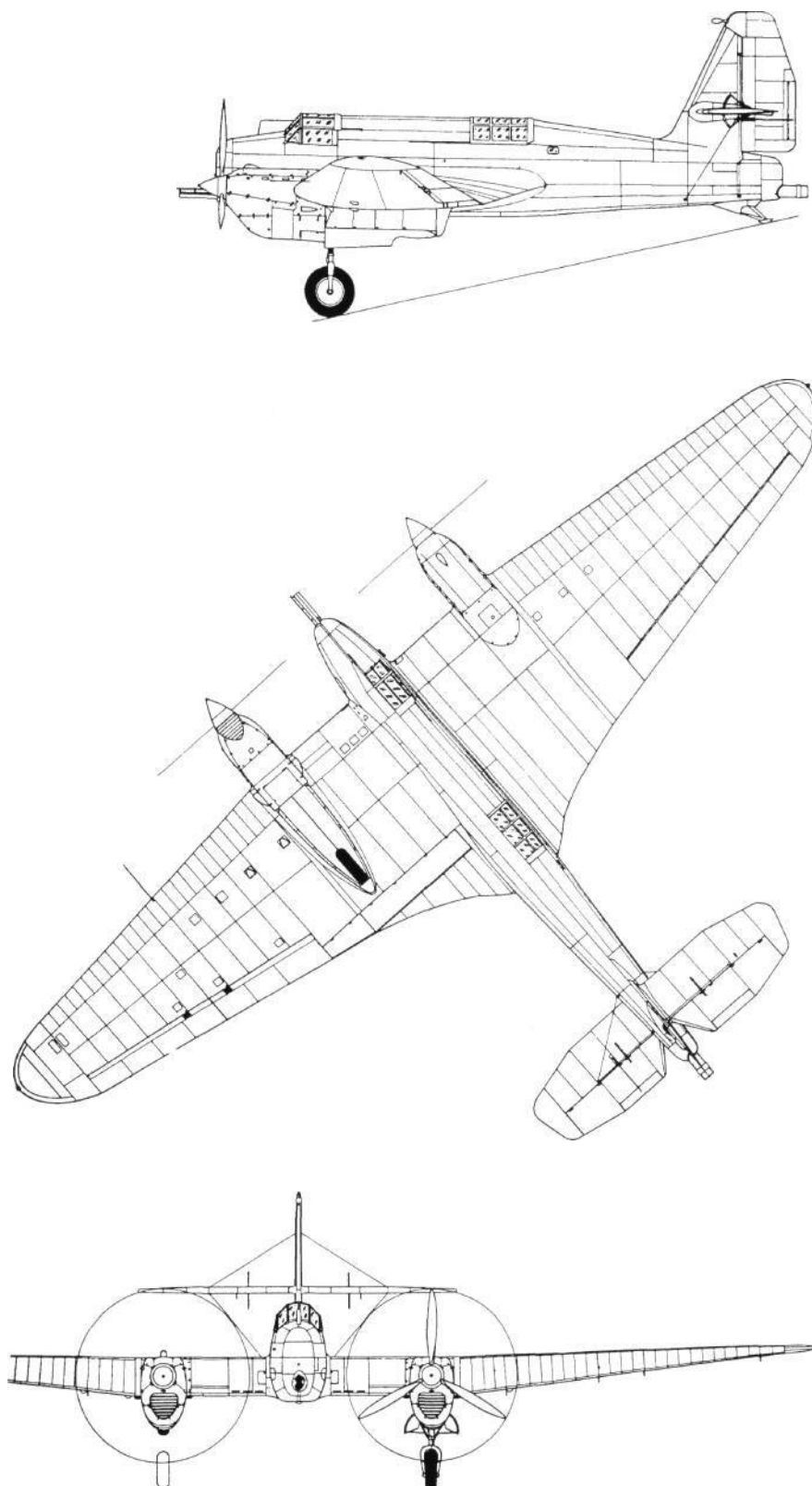
Purpose: A heavy fighter with large-calibre recoilless guns.

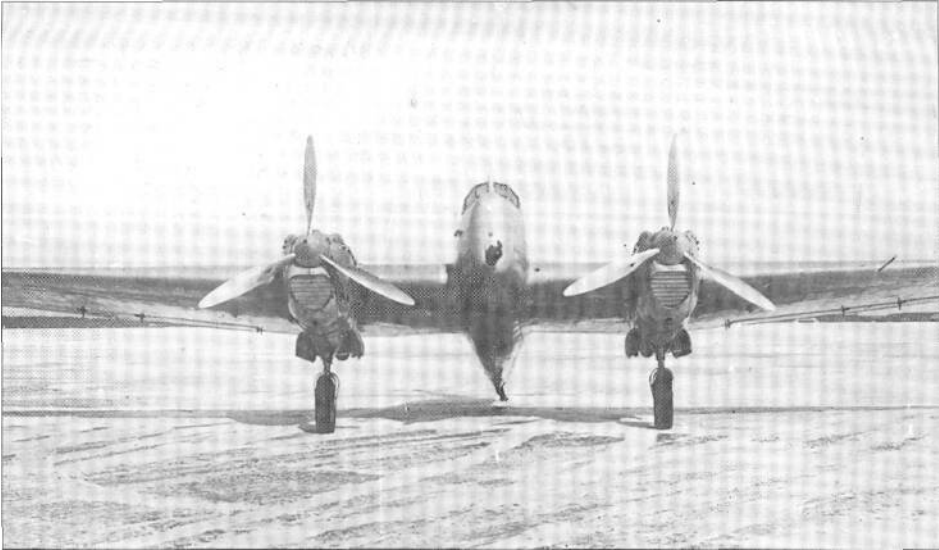
Design Bureau: KOSOS-CAHI (department of experimental aeroplane construction, central aero-hydrodynamics institute), Chief Constructor AN Tupolev.

This large fighter was a natural successor to the ANT-21 MI-3 (MI = multi-seat fighter) ordered in January 1932 and flown in May 1933. Whereas that aircraft had had conventional armament, the ANT-29 or DIP (Dvukhmestnyi Istrebitel' Pushechnyi, two-seat cannon [armed] fighter) was designed around two of the largest available calibre of APK recoilless guns (see preceding story). Funds for a single prototype were made available by the WS in September 1932. Tupolev entrusted the design to his first deputy P O Sukhoi. Normally the aircraft would have flown in about a year, but priority was given to the ANT-40 fast bomber (which flew in 1934 as the SB), and the ANT-29 was not completed until February 1935. Flight testing was started by S A Korzhinshchikov, who reported that the flight controls, especially the ailerons and rudder, were unacceptably ineffective. This prototype was returned to CAHI's ZOK (factory for prototype construction) for rectification, the main task being to re-skin the control surfaces. Testing resumed in late 1935, but by this time the ANT-46 (DI-8) was flying. The ANT-29 belonged to the previous generation, and it was abandoned in March 1936.

Like its predecessor, the ANT-21, the ANT-29 was an aerodynamically clean monoplane powered by two liquid-cooled engines. The wings were aerodynamically similar but totally different structurally, and the engines likewise were quite new. They were two of the first 760hp Hispano-Suiza 12Ybrs 12-cylinder engines to be imported into the Soviet Union. Later this engine was developed by VYaKlimov into the VK-103 and VK-105, of which over 129,000 were constructed. In this aircraft they drove imported French Chauviere three-blade variable-pitch propellers of 3.5m (138in) diameter. Carburettor air entered through a small inlet under the wing leading edge, and the radiator was in a shutter-controlled duct directly under the engine. The wing had a modern structure with two plate spars, made as a 3m (9ft 10in) horizontal centre section and 5.9m (19ft 4in) outer panels with taper and dihedral. Like the rest of the airframe the outer wing skins were smooth. In this Sukhoi broke new ground, previous 'ANT' aircraft having had corrugated metal skins showing that they originated in Junkers technology of the early 1920s. The short fuselage was of tall oval section and

ANT-29, DIP





| | | |
|-------------------------------|-----------|-------------------------|
| Dimensions | | |
| Span | 19.19m | 62 ft min |
| Length overall | 11.65m | 38ft2 ³ /4in |
| (excluding guns) | 11.1m | 36 ft 5 in |
| Wing area | 56.88 mf | 612 ft ² |
| Weights | | |
| Empty | 3,876kg | 8,545 lb |
| Fuel/oil | 720+80 kg | 1,587+176 lb |
| Loaded (normal) | 4,960kg | 10,935lb |
| (maximum) | 5,300kg | 11,684lb |
| Performance | | |
| Max speed at sea level, | 296km/h | 184 mph |
| at 4 km (13,123 ft) | 352 km/h | 219 mph |
| Time to climb 3 km (9,842 ft) | 5.6 min | |
| 5 km (16,400 ft) | 9.6 min | |
| No other reliable data. | | |



seated the pilot in the nose under a rearward-sliding canopy and a backseater over the trailing edge under a forward-sliding canopy (as in early versions of the SB). The backseater would have worked radio had it been fitted, but his main task was to check the automatic reloading of the guns and clear stoppages. The wings were fitted with large two-part ailerons and split flaps, while the tail carried the wire-braced tailplane high up the fin, the elevators and rudder having large Flettner (servo) tabs. Like the ANT-21 and SB, the main landing gears had single shock-struts with a fork carrying the axle for a braked wheel with a 900 x 280mm tyre which, after retraction to the rear, partially projected to minimise damage in a wheels-up landing. At the rear was a large tailskid. Main-gear retraction, like flap operation, was hydraulic. The primary armament comprised two APK-8 recoilless guns, also known as DRP (Dynamo-Reaktivnaya Pushka), mounted one above the other. The feed was via two chutes on opposite sides of the fuselage. Each gun

had an unrifled barrel about 4m (13ft 1in) long, with a calibre of 102mm (4in). The firing chamber was connected at the rear to a recoil tube terminating in the recoil-cancelling divergent rear nozzle, extended a safe distance behind the rudder, through which propellant gas blasted when each round was fired. Sighting was done with an optical sight in a prominent fairing ahead of the windscreen, and could be assisted by firing tracer from two 7.62mm ShKAS machine guns in the wing roots (these are shown in Shavrov's drawings, but unlike the main armament they do not appear ever to have been installed). It was intended also to fit a pivot-mounted ShKAS in the rear cockpit. There was no provision for a bomb load. Arguments over armament continued, but no attempt was made to test the ANT-29 with the alternative forward-firing armament of a 20mm ShVAK in each wing root.

By the time it was on test this was no longer an important aircraft, and (for reasons not recorded) it failed NII-WS testing.

Two views of ANT-29.

Tupolev ANT-46, DI-8

Purpose: An improved heavy fighter with large-calibre recoilless guns.

Design Bureau: KOSOS-CAHI, chief constructor A N Tupolev, who assigned this aircraft to AA Arkhangel'skii.

This aircraft was a derivative of the **SB** (ANT-40) fast bomber. The single prototype was ordered in November 1934, on condition that the SB (the first prototype of which had flown a month previously) had priority and would not in any way be delayed. The DI-8 was created quickly and was flown by Yu A Alekseyev on 1 st August (also reported as 9th August) 1935. Factory testing was continued to June 1936, but the 'liquidation' of

Kurchevskii's gun bureau and the arrest for treason and spying of Tupolev halted the programme.

Until recently little was known about the ANT-46, and only one photograph had been discovered. This did not show the nose clearly, and published accounts stated that the ANT-46 was based on the SB but had a metal-skinned nose containing machine guns. It is now known that it had a glazed nose identical to that of the bomber. Instead of being a two-seat aircraft it also had a navigator/bomb-aimer in the nose, and an internal bomb bay (for example, for eight FAB-100 bombs) with bomb doors. The interesting feature was that incorporated in each wing

outboard of the fuel tanks, between the split flaps and the ailerons, were single DRP (APK-11) recoilless guns, each fed by an automatically indexed supply of 45mm (IXin) ammunition, the rear blast tubes projecting behind the trailing edge. Like the first SB the fin and rudder had a squared-off top, and the engines were not as previously thought GR14s but, as on the first SB, nine-cylinder Wright Cyclones of 710hp, driving Hamilton two-blade propellers. Like the ANT-29, this aircraft carried CAHI titles and the ANT number 46 on the tail.

This aircraft fulfilled expectations, but was considered an outdated concept.

Dimensions

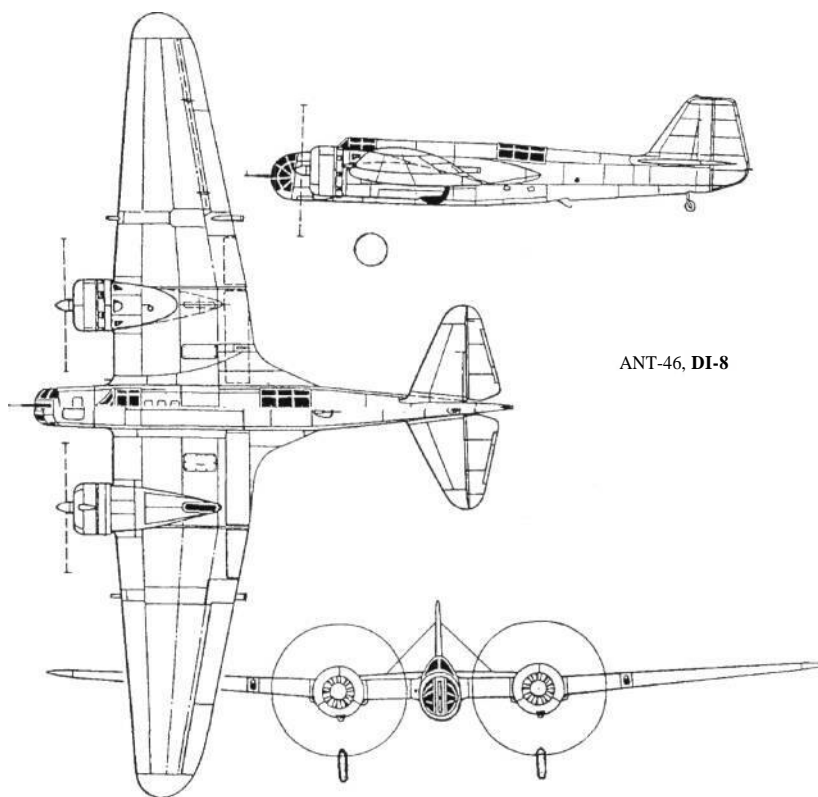
| | | |
|-----------------------------|--------------------|---------------------|
| Span | 20.33 m | 66 ft 8 in |
| Length (excluding nose gun) | 12.17 m | 39 ft 1 1/4 in |
| Wing area | 55.7m ² | 600 ft ² |

Weights

| | | |
|----------------|----------|-----------|
| Empty | 3,487kg | 7,687 lb |
| Maximum loaded | 5,553 kg | 12,242 lb |

Performance

| | | |
|-------------------------------|----------|-------------|
| Maximum speed | | |
| at 4,250m (13,944 ft) | 388 km/h | 241 mph |
| Time to climb 3 km (9,842 ft) | 6.8 min | |
| Service ceiling | 8,570 m | 28,120ft |
| Range | 1,780km | 1,100 miles |



ANT-46, DI-8

ANT-46



Tupolev Tu-2 Experimental Versions

Purpose: To use Tu-2 aircraft for various experimental purposes.

Design Bureau: Originally, CCB-29 (or TsKB-29) and GAZ (Factory) No 156.

Created during A N Tupolev's period in detention under a ludicrously false 'show trial' charge, the Tu-2 (previously 'Aircraft 103', but really the 58th 'ANT' design), was an outstanding multirole tactical bomber. Its ridiculous gestation, with its creator working on a drawing board in a locked cell, meant that it did not enter service until May 1942, but despite this some 3,300 were delivered from Factories 156, 166 and 125. As soon as spare examples became available they were snapped up for use as test-beds. The very first series aircraft, No 100716, was used to test the ASh-83 engine, rated at 1,900hp, driving four-blade AV-5V propellers (replacing the standard 1,850hp ASh-82FN driving the three-blade AV-5V-167 or four-blade square-tip AV-9VF-21K). Maximum speed of this test-bed was 635km/h (395mph) at 7,100m (23,294ft).

Numerous test versions appeared in 1944, including the first two of three Shturmovik (armoured ground attack) versions with special armament, all proposed by Tupolev's armament brigade leader A D Nadashkevich. The first, actually given the designation Tu-2Sh, had its capacious weapon bay occupied by a specially designed aluminium box housing 88 modified PPSH-41 infantry ma-

chine carbines (sub-machine guns). These fired standard 7.62mm pistol ammunition, and all fired together pointing obliquely down at a 30° angle. The obvious shortcoming was that, even though the drum magazines held 71 rounds, they were quickly emptied.

The second 1944 Sh version had a massive 75mm gun under the fuselage, reloaded by the navigator. Two more ground-attack versions appeared in 1946. The first had the devastating forward-facing armament of two 20mm ShVAK, two NS-37 and two NS-45. The 37mm gun was 267mm (10 1/2in) long and weighed 150kg (331lb). The 45mm version had a shorter barrel but still fired its 1.065kg (2.35 lb) projectiles at 850m (2,790ft) per second, and weighed 152kg (335 lb).

The last of these variants was the two-seat RShR, or Tu-2RShR. This was a dedicated anti-armour aircraft, carrying a high-velocity 57mm RShR automatic cannon with the barrel projecting ahead of the metal-skinned nose and fitted with a prominent recoil brake.

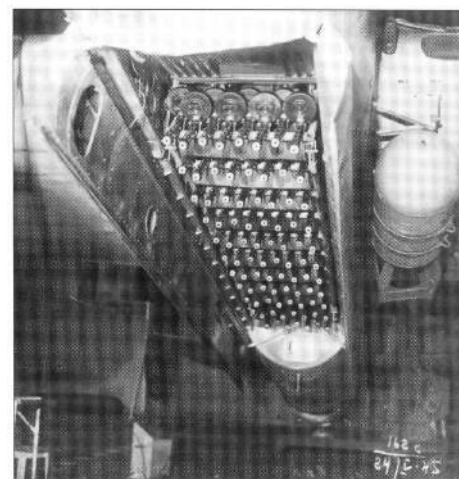
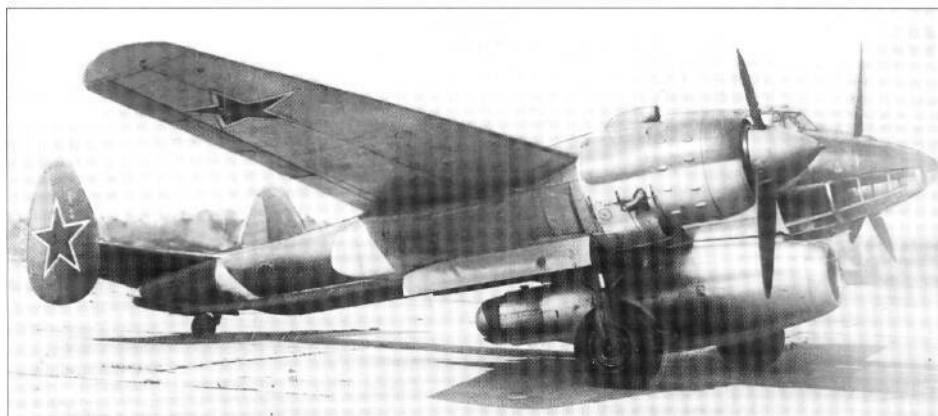
The most startling modification was the Tu-2 Paravan (paravane). Two of these were built, to test a crude way of surviving impact with barrage-balloon cables. A special cable woven from high-tensile steel was run from one wingtip to the other via the end of a monocoque cone projecting over 6m (20ft) ahead of the nose. The nose and wingtips were reinforced. First flown in September 1944, this lash-up still reached 537km/h (334mph) despite the strange installation and

a 150kg (331 lb) balancing weight in the tail. These trials were not considered to have been successful.

Yet another 1944 modification was the Tu-2K (Katapult), fitted with test ejection-seats. The first Tu-2K fitted the test seat in the navigator's cockpit just behind the pilot. A second ejection-seat tester had the experimental seat mounted in an open cockpit at what had been the radio operator's station in the rear fuselage.

In early 1945 the Type 104 radar-interception system began flight testing (the first to be airborne in the Soviet Union). The system had been designed from 1943, by a team led by A L Mints, and the Type 104 test aircraft had begun flight testing on 18th July 1944 but with the vital radar simulated by ballast. The pilot had a modified sight, which was later linked to the radar, and fired two VYa-23 cannon installed under the forward fuselage. The rear fuselage was faired over and contained nothing but a balancing mass.

The designation Tupolev Tu-2G was applied to several Gruzovoi (cargo) conversions. It appears that all of these were experimental, carrying special loads either in the remarkably large bomb bay or slung externally, and in many cases the load was dropped by parachute. No fewer than 49 GAZ-67b armoured reconnaissance cars were dropped, the Tu-2G in this case being limited to a height of 6km (19,685ft) and a speed of 378km/h (235mph).



Above left: Tu-2LL testing RD-45 (copy of Rolls-Royce Nene).

Above: Looking into the weapon bay of Tu-2Sh.

Left: Tu-2 Paravan.

As explained in the stories of the Pe-2 and Pe-8 experimental versions, the German Fi 103 ('V. 1') flying bomb was the basis for a large Soviet programme of air-launched cruise missiles in the immediate post-war era. One of the later variants was the 16Kh Priboi (surf, breaking waves). The fact this was fitted with twin engines meant that it could be carried under the Tu-2. The first modified Tu-2 launch aircraft began testing at LII on 28th January 1948, and live missile launchings took place on the Akhtuba range between 22nd July and 25th December 1948, testing the D-312 and D-14-4 engines and various electric or pneumatic flight-control systems. The Tu-2 launch aircraft continued in the

process of refining guidance and improving reliability until at least 4th November 1950, by which time the Tu-4 was being modified as carrier aircraft with one missile under each outer nacelle. The WS rejected the 16Kh on grounds of poor accuracy, and eventually the argument reached Stalin who shortly before his death terminated this missile.

Experimental Tu-2 aircraft were also used to develop air-refuelling.

Not least, in the immediate post-war era the Tu-2 was the most important aircraft converted to air-test turbojet engines. Occasionally the designation Tu-2LL (flying laboratory) was used, but one of the most important was (possibly unofficially) designated Tu-2N,

because it was allocated to test the imported Rolls-Royce Nene. This required the test engine to be mounted in a nacelle of large diameter (basic engine diameter 1.26m, 4ft 11/2in). Later more than one Tu-2 was used to test Soviet RD-45 and VK-1 derivatives of the Nene, including variants with an afterburner. However, these were all preceded by aircraft, some of which had been Tupolev Type 61 prototypes, which were converted to test captured German axial engines: the BMW 003A (Soviet designation RD-20) and the Junkers Jumo 004B (Soviet designation RD-10). Another 61 prototype was used to test the first Soviet turbojet to fly, the Lyul'ka TR-1, in 1946.

Tupolev Tu-4 Experimental Versions

Purpose: To use Tu-4 aircraft for various experimental purposes.

Design Bureau: OKB-156 of AN Tupolev.

In The Great Patriotic War the Soviet Union had no modern strategic bomber. Stalin cast covetous eyes on the Boeing B-29, and told Tupolev and Myasishchev to design aircraft in the same class. However, in 1944 three intact B-29s fell into Soviet hands and it was decided just to copy them. Tupolev was given two years to do this immense task. The first aircraft to appear was the Tu-70 transport, which actually used the wing, engines and propellers of one of the B-29s. The production bomber was designated Tu-4, and had Soviet ASh-73TK engines of 2,400hp (more powerful than the B-29 engine) and a totally new defensive system with guns of 12.7mm (1st Series), 20mm (from the 8th Series) or 23mm calibre (from the 15th Series). Total production was close to 1,000. Several Tu-4 aircraft were used in air-refuelling experiments.

The Tu-4T was a single unpressurized transport conversion which initially was used for trials with 28 paratroops. In 1954 a small number

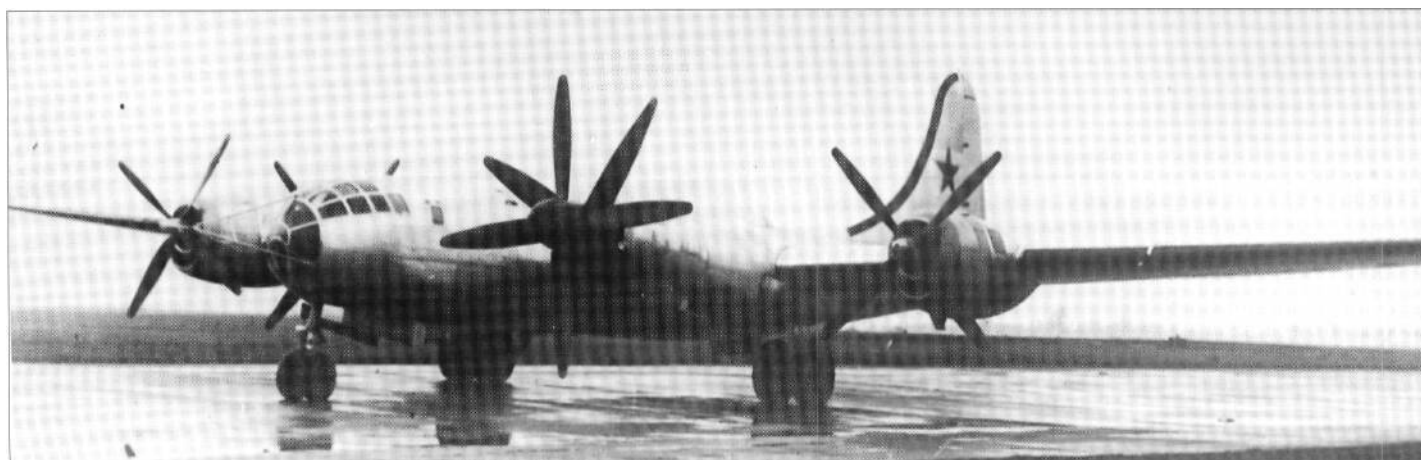
of 52-seat versions, again called Tu-4T, were built for the VTA (military transport aviation).

Several Tu-4K conversions were used as carrier aircraft for trials with the Mikoyan KS-1 cruise missile, for use chiefly against ships. This 3 tonne (6,614lb) turbojet-engined weapon was a miniature swept-wing aeroplane with radar guidance (see page 101). The Tu-4K played a major role in the development of the entire Kompleks (electronic system) which after being cleared for production was installed in the Tu-16KS, which was the operational carrier of these missiles. Several Tu-4s were used for trials with other missiles, the earliest being with captured FiLOS (so-called V-1) pulsejet cruise missiles captured in 1944-45. From March 1945 the Soviet X-10 (Kh-10) copy was on test, and numerous examples were launched from ground ramps and from Tu-2, Yer-2 and Pe-8 aircraft. In 1947 the Tu-4 became available, and several were used to test the 14Kh-1 and twin-engined 16Kh, but all this work petered out by July 1955 and none of these missiles entered service.

At least 12 Tu-4s were used as engine test-

beds. Some of the early examples tested turboprops, of which the most startling were the three aircraft whose No 3 (starboard inner) engines were replaced by TV-12 turboprops. Take-off power of this single-shaft engine was initially 11,995hp, or almost six times that of the engine it replaced. The colossal thrust, which in the Tu-4 could not all be used, was transmitted by a pair of AV-60 co-axial propellers each with four broad blades of 5.6m (18ft 4 1/2in) diameter. Later this unique powerplant was developed into the NK-12M of nearly 15,000hp for the Tu-95 and Tu-142. Other turboprops tested included the ex-Junkers TV-2, Klimov VK-2 (TV-4), Kuznetsov NK-2 and NK-4, and the Ivchenko AI-20, one AI-20 installation (for the Ilyushin 18) having the thrust line and jetpipe above the wing and the other (for the Antonov 10 and 12) having the thrust line and jetpipe below the wing. Jet engines tested under the fuselage of Tu-4LL aircraft included the Nene, AL-5, AL-7, 7F and 7P, AM-3 (RD-3), AM-5 and 5F, VD-5, VD-7, VK-2, VK-7 and VK-11.

Tu-4 test-bed for NK-12 turboprop.



Tupolev Tu-16 Experimental Versions

Purpose: To use Tu-16 aircraft for various experimental purposes, and to take the basic design further.

Design Bureau: OKB-156 of A N Tupolev, Moscow.

This graceful twin-jet bomber sustained what was in financial terms the most important programme in the entire history of the Tupolev design bureau up to that time. Since then, because of inflation, the Tu-154 and Tu-22/Tu-22M have rivalled it, though they were produced in smaller numbers. The prototype Tu-16, the Type 88, was a marriage of upgraded B-29 technology in structures, systems and to some degree in avionics, with totally new swept-wing aerodynamics and what were in the early 1950s super-power turbojet engines. The Tu-16 entered production in 1953 powered by Zubets (Mikulin KB) RD-3M engines of 8,200kg (18,078lb) thrust. The second series block had the RD-3M-200 of 8,700kg (19,180lb) followed by the 9,500kg (20,944lb) RD-3M-500, which was then retrofitted to most earlier aircraft.

From 1953 the basic aircraft was repeatedly examined against alternatives based as far as possible on the same airframe but using different propulsion systems. Most of the studies had four engines. Tupolev had originally schemed the 88 around two Lyul'ka AL-5 turbojets, but the design grew in weight to match the big AM-3 engine, and this was the key to its win over the smaller Ilyushin with the Lyul'ka engines. In parallel with the

production aircraft one project team led by Dmitri S Markov studied versions of the 88 with not two but four AL-5 engines, and then four of the more powerful (typically 14,330lb, 6,500kg) AL-7 engines. These Type 90s would have been excellent bombers, with increased power and much better engine-out performance, but the decision was taken not to disrupt production. On the other hand, virtually the same inboard wing and engine installation was then used in the Tu-110 transport, two of which were built using the Tu-104 as a basis. Some of the four-engined bomber studies had engines in external nacelles hung on underwing pylons.

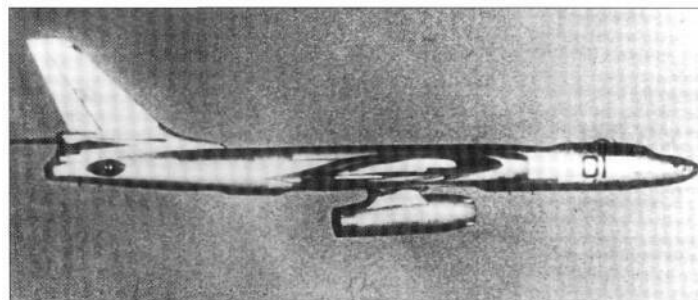
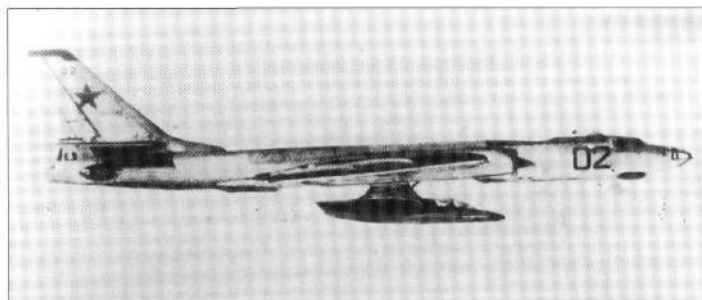
From 1954 Type 88 prototypes and a wide range of production Tu-16s were used over a period exceeding 40 years as experimental aircraft. Some carried out pioneer trials in aerial refuelling at jet speeds.

One large group of about 20 aircraft was kept busy in the development of avionics, including navigation, bombing and cartographic guidance, parent control of drones and targets, and the direction of self-defence gunnery systems.

Probably the most important single duty of Tu-16LL (flying laboratory) aircraft was to air-test new types of turbojet and turbofan engine. In each case the engine on test would be mounted in a nacelle either carried inside the weapon bay or, more often, recessed into it. Usually the test engine would be suspended on vertical hydraulic jacks or a large pivoted beam so that in flight it could be extended

down fully into the airstream, with its efflux well clear of the rear fuselage. In many cases the engine pod or the Tu-16 fuselage ahead of it would be fitted with a fairing or door which could be left behind or opened as the pod was extended for test. Among the engines air-tested under Tu-16LL aircraft were: the Ivchenko (later Progress) AI-25, Lyul'ka AL-7F-1, AL-7F-2, AL-7F-4 and AL-31F, Solov'yov (Aviadvigatel) D-30, D-30K, D-30KP and D-30F6 (in MiG-31 installation), Lotarev (Ivchenko Progress) D-36, Kuznetsov NK-6 (with and without afterburner) and NK-8-2, Tumanskii (Soyuz)R-11AF-300(Yak-28nacelle)andR-15-300 (in the Ye-150 and the totally different MiG-25 installation),MetskhvarishviliR-2I-300and R-21Fwith Ye-8 inlet, Khachaturov R-27 versions (including the vectored R-27V-300 in a complete Yak-36M prototype fuselage, Mikulin (Soyuz) RD-3M (many versions), Kolesov (RKBM) RD-36-41 and RD-36-51, and Dobrynin (RKBM) VD-7, VD-7M and VD-19 (in a proposed Tu-128 installation), etc.

One Tu-16 had its entire nose replaced by that intended for the Myasishchev M-55, in order to test the comprehensive suite of sensors. Another tested a scaled version of the bogie main landing gear for the Myasishchev M-4 and 3M strategic bombers, replacing the normal nose landing gear. A new twin-wheel truck was added at the tail. According to documents a Tu-16 with outer wings removed tested the complete powerplant of the Yak-38 (presumably in free hovering flight) though photographs have not been discovered.



Above left: Tu-16LL with AI-25 turbofan on test in mock-up Aero L-39 fuselage.



Left and above right: Tu-16LL used to test two different (unidentified) large turbofans, one shown retracted and the other extended.

Tupolev Tu-155

Purpose: To investigate the use of cryogenic fuels.

Design Bureau: ANTKANTupolev, Moscow. Technical Director Valery Solozobov, cryogenic fuels Chief Designer Vladimir Andreyev.

For many years the USSR and its successor states have been replacing petroleum by natural gas, which in 1999 provides over 53 per cent of the total of all Russia's energy supplies. Since 1982 what is today ANTK Tupolev has been investigating the use of natural gas and also hydrogen as fuels for aircraft, because of their availability and clean burning qualities. However, for use in vehicles both have to be liquefied by being cooled to exceedingly low temperatures. Liquid hydrogen (LH₂) boils at -255°C, an unimaginably low temperature at which (for example) all conventional lubricating oils are rock-solid. Moreover, this fuel is very expensive, and hazardous from the viewpoints of detonation and fire. On the other hand, liquefied natural gas (LNG) is widely available, at least threefold cheaper in Russia than aviation kerosenes, and also significantly improves flight performance. It is straightforward to store and han-

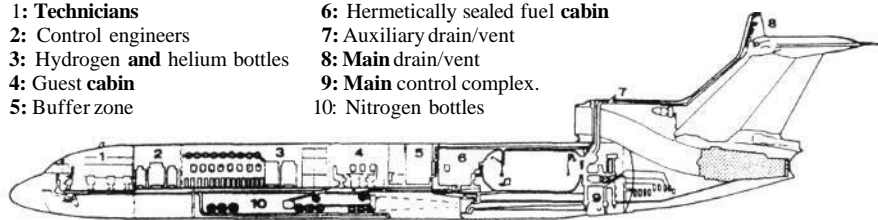
die, and less fire/explosion hazardous even than today's kerosenes. After years of laboratory work an existing civil transport was selected for use as an LNG flight test-bed. It has been flying since 1988. All work is now directed at the Tu-156, the first LNG aircraft designed to go into service.

Toflight-testanLNGsystemANTKTupolev bailed back a Tu-154, No 85035, and replaced the No 3 (starboard) engine with an NK-88, fed with LNG by a completely separate fuel system. The NK-88 is a derivative of the Kuznetsov NK-8-2 turbofan (still fitted in the Nos 1 and 2 positions), with thrust unchanged at 20,945 lb (9,500kg). The successor to Kuznetsov's bureau is Samara/Trud. The complex feed system is shown in a drawing. The main tank, of 10ft 2in (3.1m) diameter and 17ft 8 1/2in (5.4m) long, is of AMG6 aluminium alloy, with a 50mm (2in) lagging of foamed polyurethane. The NK-88 engine has a dedicated two-stage centrifugal pump driven by a bleed-air turbine. LNG comes in at -152°C and is passed through a heat ex-

changer to convert it to gas. The engine combustion chamber is able to accept either this supply of NG or, on command, to switch to the kerosene supply normally used for the other engines. Work is still underway on a low-emissions chamber which will be used on the improved NK-89 engine to be fitted to the Tu-156. The definitive Tu-156 is expected to have the fuel in giant saddle tanks along the top of the fuselage. Instead, to reduce time and cost, at least the first Tu-156 has a main tank (capacity 28,660lb, 13 tonnes) behind the passenger cabin and, to preserve centre of gravity position, an auxiliary tank (8,377 lb, 3,800kg) in the forward underfloor baggage hold. This reduces payload from 18 tonnes to 14 (30,864 lb). Range will be 1,616 miles (2,600km) on LNG only, or 2,051 miles (3,300km) on combined LNG and kerosene.

Eventually the Earth's store of petroleum will run dry. It is pointless to say 'More keeps being discovered'. The world's aircraft will then have no alternative but to switch to another fuel, and LNG is the obvious choice.

- | | |
|--------------------------------|-----------------------------------|
| 1: Technicians | 6: Hermetically sealed fuel cabin |
| 2: Control engineers | 7: Auxiliary drain/vent |
| 3: Hydrogen and helium bottles | 8: Main drain/vent |
| 4: Guest cabin | 9: Main control complex. |
| 5: Buffer zone | 10: Nitrogen bottles |



Internal arrangement of the Tu-155

Below: Tu-155.

Photographs on the following page:

Left: Tu-155 interior.

Right: Model of Tu-156.





Experimental Test-beds

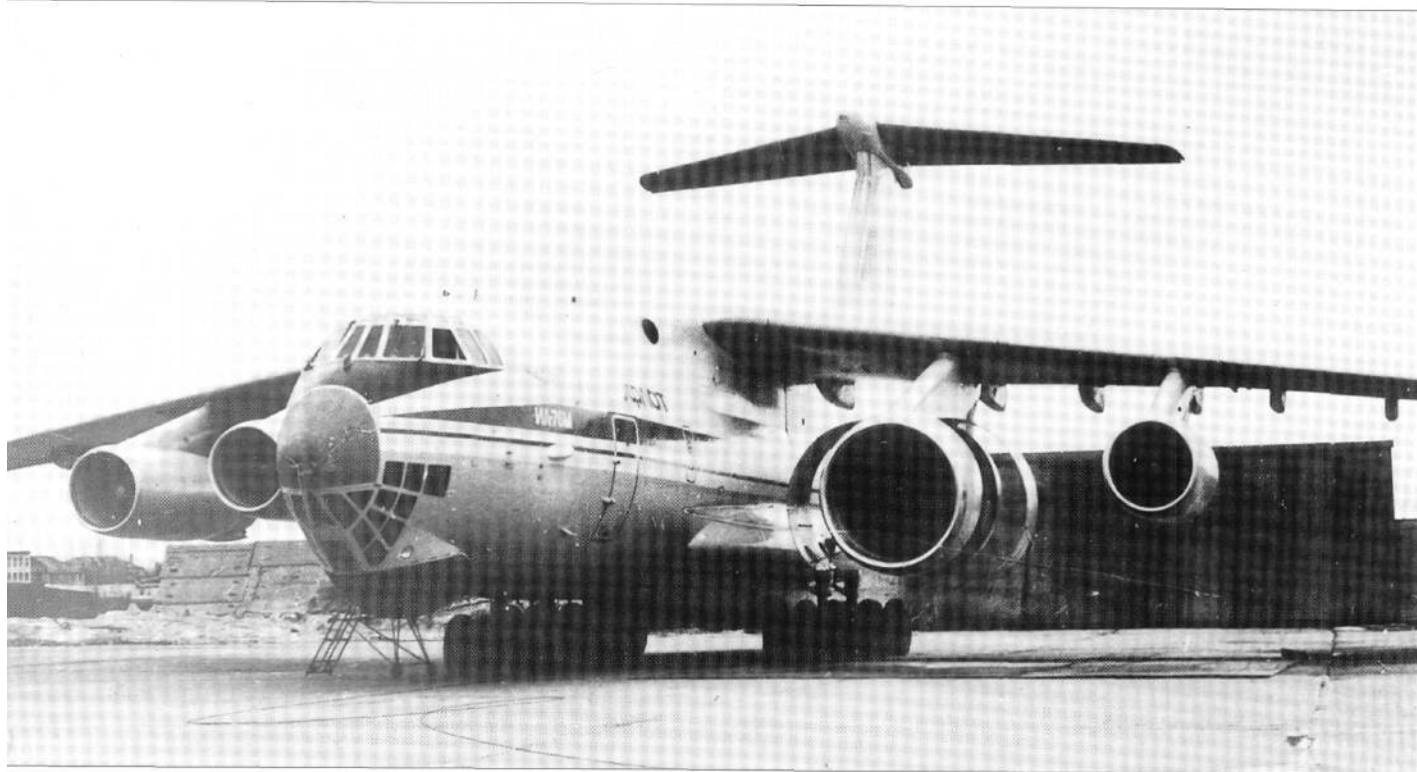
Purpose: To use established aircraft to flight-test experimental items.

Design Bureau: Various.

In Russia flying test-beds are as a class called by the suffix initials LL, from Letayushchaya Laboratoriya, flying laboratory. One of the most important LL tasks is to flight-test new types of engine. Several experimental engines have appeared in this book already, for example rockets to boost the speed and altitude of fighters, and the awesome TV-12 turboprop tested on a Tu-4. Until the 1980s the most important LL for flight-testing engines was the Tu-16. As explained in the entry on

that aircraft, engines had to be installed for testing in or under its bomb bay. In recent years the Ilyushin IL-76 has come to the fore as a totally capable engine test-bed, handicapped only by its considerable size and operating cost. Originally designed as the IL-76M military transport, this superb aircraft is an ideal LL on which to hang virtually any type of aircraft propulsion system, usually using the No 2 (port inner) underwing pylon attachment. A considerable fleet of IL-76 aircraft is available in former Soviet territories. Several are operated by the Gromov Flight Research Institute (or LII), and are available for hire. Their interiors are already packed with sen-

sors and loggers, computers, oscilloscopes and many kinds of instrumentation, overseen by a test and research crew which usually numbers five. The flight crew typically numbers three. Among the engines tested are the NK-86, D-18T and PS-90A turbofans, and the D-236 and NK-93 propfans. One of the photographs shows a former IL-76M used for testing large turbofans of the D-18 family. The other shows a former civil IL-76T used to test the TV7-117S turboprop and its six-blade Stupino SV-34 propeller. The propeller blades are heavily strain-gauged, the instrumentation cable being led forward from the tip of the spinner.

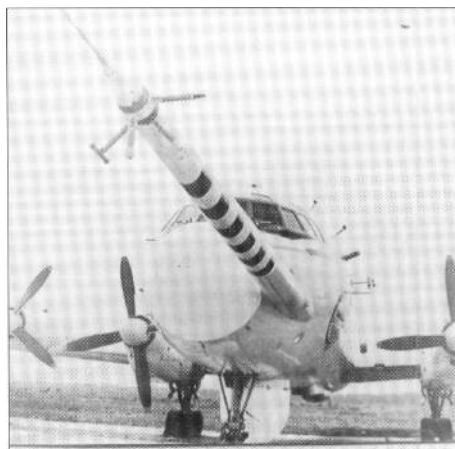




Another Ilyushin aircraft used in significant numbers as an experimental test-bed is the IL-18. Possibly as many as 30 have been used, mainly at the Zhukovskii and Pushkin test centres, for upwards of 50 test programmes. Nearly all are basically of the IL-18D type, powered by four 4,250hp AI-20M turboprops. The most famous of these aircraft is the IL-18 No 75442, named Tsyklon (cyclone). Instantly recognisable from its nose boom like a jousting lance, this meteorological research aircraft is equipped with something in excess of 30 sensors used to gather data about atmospheric temperature, pressure and pressure gradient, humidity, liquid and solid particulate matter (including measurement of droplet and particle sizes) and various other factors which vary according to the mission. The sensors extend from nose to tail and from tip to tip. Other IL-18 and IL-18D aircraft have helped to develop every kind of radar from fighter nosecones to giant SLARs (slide-looking airborne radar) and special mapping and SAR (synthetic-array radar) installations.

A small number based at Pushkin tested the main radars and pointed radomes of supersonic aircraft, though this was done mainly by the Tu-134.

Total production of the Tu-134 passenger twin-jet was 853. Of course, the majority were delivered to Aeroflot and foreign customers, but a few went to the WS. From the mid-1970s aircraft built as passenger transports began to be converted for use as military crew trainers, including the Tu-134BU for military and civil pilots to Cat IIIA (autoland) standard, Tu-134Sh for navigators and visual bomb aimers (actually dropping bombs to FAB-250 (551 lb) size), Tu-134BSh for Tu-22M



Top: IL-76LL with TV7-1 ITS

Centre: Nose of IL-18 Tsyklon

Bottom: Tu-134 radar testbed

Opposite page, bottom: IL-76LL with D-18T



Above: Tu-134 radar testbed

Left: Tu-134IMARK

Centre left: IL-28 for ski research

Bottom: Yak-25M testing Yak-28 engine icing



navigators and bomb-aimers, and Tu-134UBL for Tu-160 pilots. These are not experimental, nor is the Tu-134SKh with comprehensive nav aids and avionics for worldwide land-use and economic survey. On the other hand at least 15 aircraft were converted for equipment testing and research. One has flown over 6,000 hours investigating the behaviour of equipment and Cosmonauts under weightless (zero-g) conditions. Several have been fitted with nose radars under development for other aircraft, including the installations for the Tu-144, Tu-160 and MiG-29. With the designation IMARK, aircraft 65906 has tested the Zemai polarized mapping radar able to operate on wavelengths of 4, 23, 68 or 230cm (from \sqrt{Am} to 7ft 7in). Arrays of antennas look down and to the right side from the starboard side of the fuselage and a large ventral container. A generally similar but more versatile test aircraft is 65908. This is based at Zhukovskii together with a Tu-134 fitted with a giant parachute in the tail for emergency use during potentially dangerous research into deep-stall phenomena, which caused the loss of several aircraft with T-tails and aft-mounted engines.

Photographs show two other aircraft from the many hundreds used in the former Soviet Union for special tests. One shows an IL-28 used for research into the design, materials and behaviour of skis on different kinds of surface. A large ski mounted under the bomb bay near the centre of gravity could be rammed down against the ground by hydraulic jacks. On the ski were test shoes of different sizes, shapes and materials. The other photograph shows the Yak-25 test-bed fitted on the starboard side with the engine installation proposed for the Yak-28, with a sharp lip and moving central cone. Ahead of it was a water spray rig for icing trials.

Vakhmistrov Zveno

Purpose: To enable a large aircraft to carry one or more small ones long distances, for example to attack targets that would otherwise be out of reach.

Design Bureau: Not an OKB but engineer Vladimir Sergeyevich Vakhmistrov working at the LII (flight research institute).

In 1930 Vakhmistrov suggested that a cheap glider might be used as an aerial gunnery target, and he quickly perfected a way of carrying such a glider above the upper wing of an R-1 reconnaissance aircraft and releasing it in flight. This gave Vakhmistrov the idea of using a large aircraft to carry a small one on long-range flights over hostile territory. The small aircraft could either be fighters to protect a large bomber, or bomb-carrying attack aircraft or camera-carrying fast reconnaissance aircraft which could make a pass over a target while the parent aircraft stood off at a safe distance. In each case the difficult part was hooking on again for the long flight home. After presenting the WS and LII management with calculations Vakhmistrov received permission to try out his idea. This led to a succession of Zveno (link) combinations:

Z-1

This featured a twin-engined Tupolev TB-1 bomber carrying a Tupolev I-4 fighter above each wing. The fighters were of the I-4Z version, three of which were converted for these experiments with short stub lower wings and attachment locks on the landing gear and under the rear fuselage. The bomber was provided with attachments for the Zveno aircraft above each wing: two small pyramids for the landing gear and a large tripod for the rear fuselage attachment.

The first flight took place from Monino on 3rd December 1931. The TB-1 was flown by AI Zalevskii and A R Sharapov, with Vakhmistrov as observer. The fighters, with ski landing gears, were flown by V P Chkalov and A S Anisimov. The take-off was made with the fighter engines at full power. The TB-1 copilot forgot the release sequence and released Chkalov's axle before releasing the aft attachment, but Chkalov reacted instantly and released the rear lock as the fighter reared nose-up. The second fighter was released correctly. For a few seconds the TB-1 flew with no tendency to roll with an I-4Z on one wing.

Z-1a

First flown in September 1933, this comprised the TB-1 carrying two Polikarpov I-5 fighters. The latter were fitted with a reinforcing plate under the rear fuselage carrying the rear hold-down, but had no special designation. The pilots were P M Stefanovskii (TB-1) and I F Grodz' and V K Kokkinaki (I-5).

Z-2

This was the first of the more ambitious hook-ups using a TB-3 as parent aircraft. The bomber was an early TB-3/4 M-17, and it was given attachments for an I-5 above each wing and a third above the fuselage with its wheels on a special flat platform. On the first test in August 1934 the TB-3 was flown by Zalevskii and the fighters by T P Suzi, S P Suprun and T T Al'tnov.

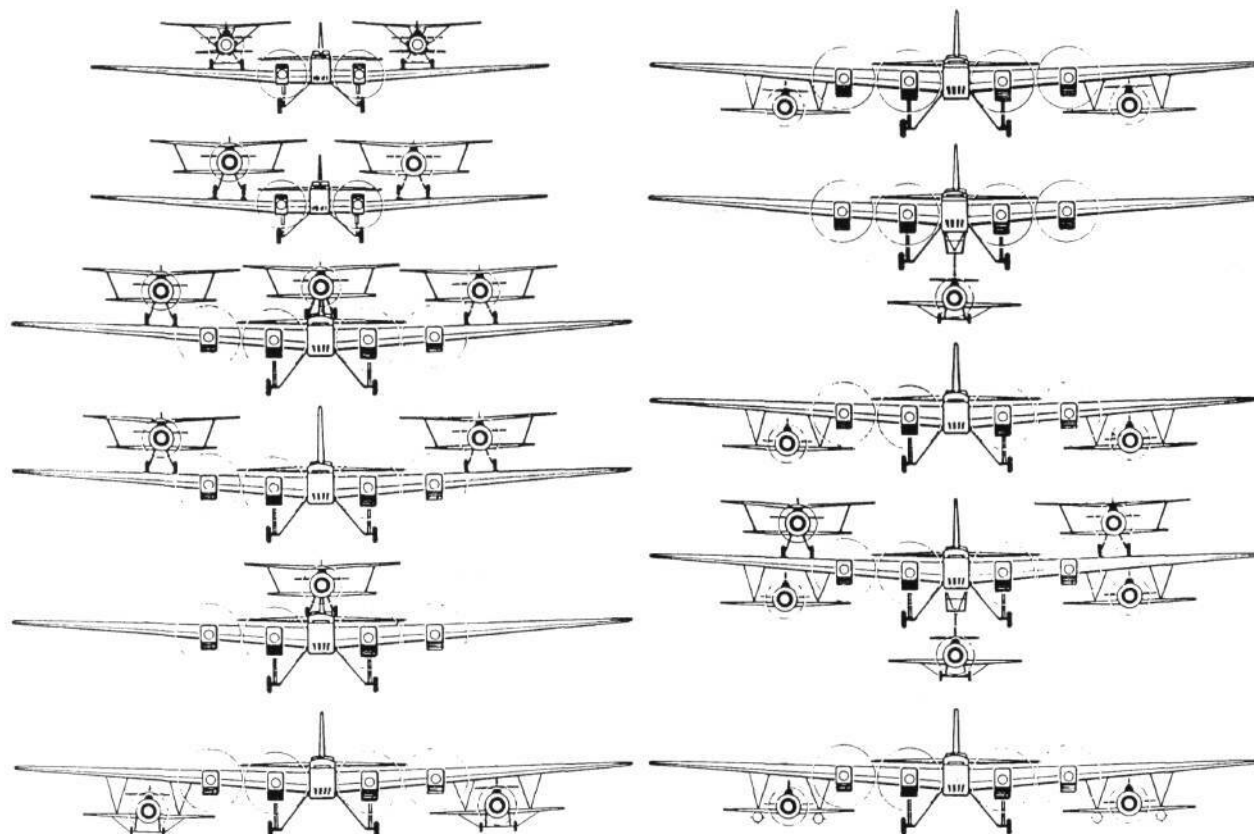
Z-3

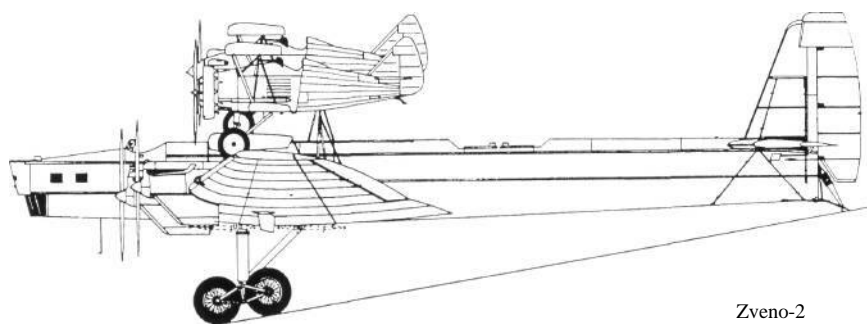
This combination would have hung a Grigorovich I-Z monoplane fighter under each wing of the TB-3. It was not flown.

Z-4

No information.

The complete sequence of Zveno developments (not all were tried).





Top: Preparing Zveno-1.

Centre: Zveno-2.

Bottom: Zveno-5.

Photographs on the opposite page

Right: Zveno-6.

Centre right: Aviamatka flypast.

Centre left: Detail of I-16 suspension for SPB.

Bottom: SPB; this was partly a Tupolev programme.

Z-5

This was the first attempt to hook back on. The parent aircraft was again the TB-3/4 M-17, and the fighter was an I-Z fitted with a large suspension superstructure of steel tubes, plus a curved upper guide rail terminating in a sprung hook releasable by the pilot (almost identical to the arrangement used on the airship-borne US Navy F9C Sparrowhawks). This was designed to hook on a large steel-tube trapeze under the bomber, which was folded up for take-off and landing. V A Stepanchyonok flew the I-Z on several tests with the bomber flown as straight and level as possible by Stefanovskii. The first hook-on took place on 23rd March 1935; this was a world first.

Z-6

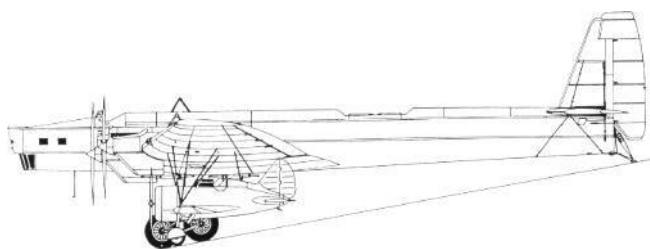
The final combination of the original series was the mating of two I-16 monoplane fighters hung under the wings of the TB-3. The fighters were provided with local reinforcement above the wings to enable them to be hung from sliding horizontal spigots on large tripod links of streamlined light-alloy tube pin-jointed to the bomber's wing structure. Bracing struts linked the bomber to a latch above the fighter's rear fuselage, and one of the fighters (M-25A-engined No 0440) was photographed with a lightweight pylon above the forward fuselage to pick up under the bomber's wing. The first test took place in August 1935; Stefanovskii flew the TB-3 and the fighter pilots were K K Budakov and AI Nikashin.

Aviamatka

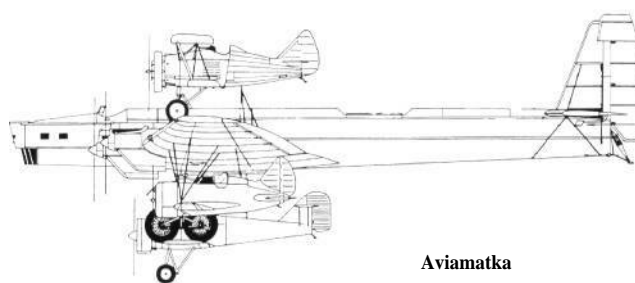
Named 'mother aircraft', this amazing test, not part of the original plan, took place in November 1935. The TB-3/4M-17 took off from Monino with an I-5 above each wing and an I-16 below each wing. At altitude it folded down the under-fuselage trapeze and Stepanchenok hooked on the I-Z, making a combination of six aircraft of four types all locked together. After several passes all the fighters released simultaneously. By this time Vakhmistrov had schemes for up to eight fighters of later types all to be carried by large aircraft such as the full-scale VS-2 tailless bomber projected by Kalinin. Instead Stalin's 'terror' caused the whole effort to wither, but there were still to be further developments.

SPB (Russian initials for fast dive bomber)

This was a special version of the Polikarpov I-16 equipped with a rack to carry an FAB-250 (bomb of 250kg, 551 lb) under each wing. Such an aircraft could not have safely taken off from the ground. In 1937 a later TB-3/4AM-34RN was made available, and two SPB aircraft were hung under its wings. The first test took place on 12th July 1937, the TB-3 being flown by Stefanovskii and the dive bombers by A S Nikolayev and IA Taborovskii.



Zveno-6

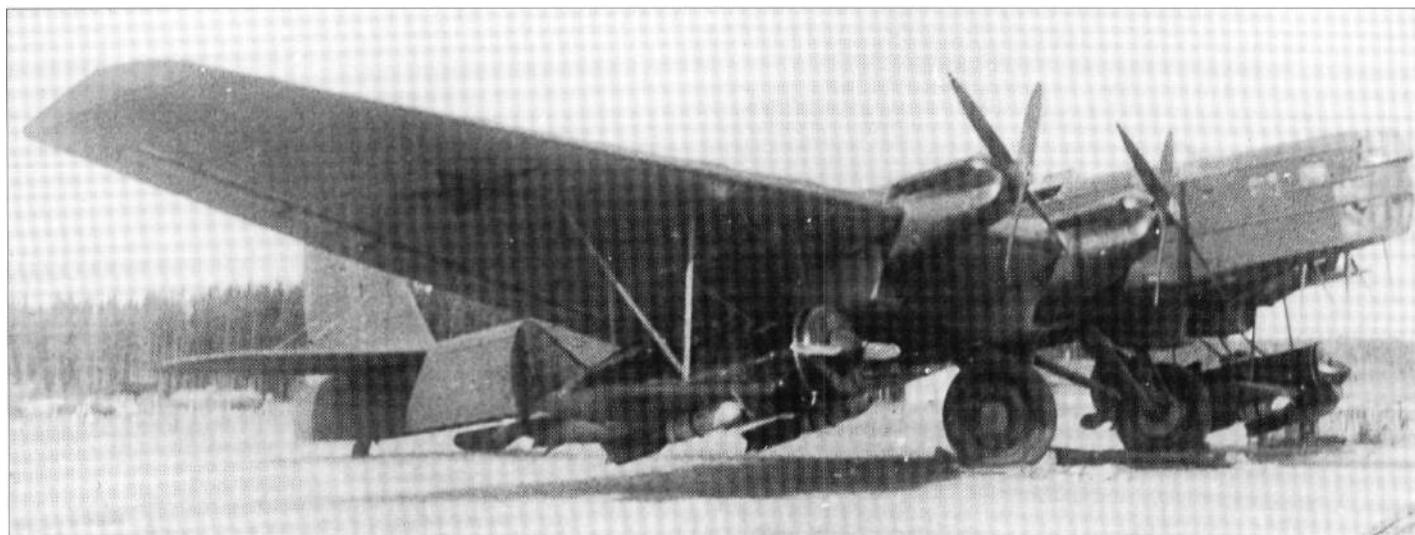
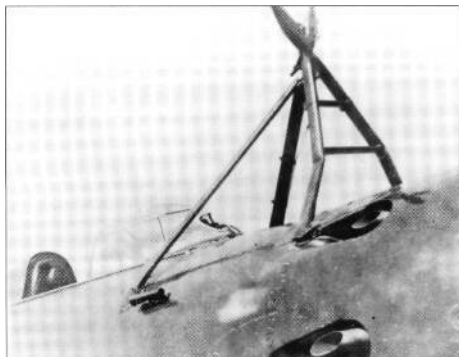
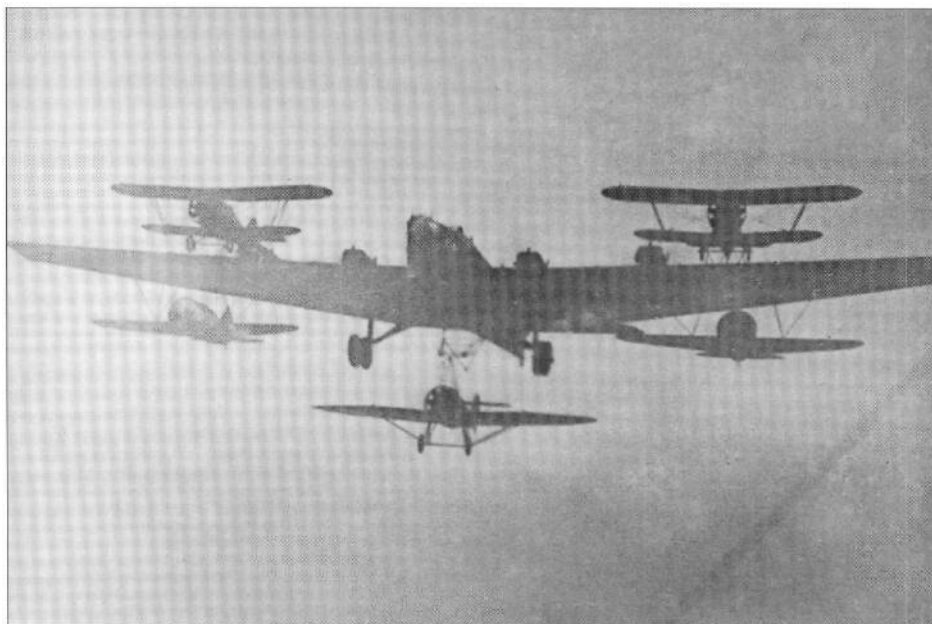


Aviamatka

Z-7

In November 1939 one final combination was flown: the TB-3/4AM-34RN took off with an I-16 under each wing and a third hooked under the fuselage in flight (with severe difficulty). The I-16 pilots were Stefanovskii, Nyukhtikov and Suprun.

In early 1940 the WS decided to form a Zveno combat unit. Based at Yevpatoriya, this was equipped with six modified TB-3/4AM-34RN and 12 SPB dive bombers. During the Great Patriotic War a famous mission was flown on 25th August 1941 which destroyed the Danube bridge at Chernovody in Romania, on the main rail link to Constanta. Surviving SPBs flew missions in the Crimea.



Yakovlev Experimental Piston Engineed Fighters



Purpose: to modify established aircraft for experimental purposes.

Design Bureau: OKB of A S Yakovlev, evacuated to Factory No 153 at Novosibirsk until in late 1944 it returned to Factory 115 on Leningradskii Prospekt, Moscow.

From the pioneer Yak-1 (I-26) fighter Yakovlev derived the UTI-26 two-seat trainer, which in turn was 'reverse-engineered' into the Yak-7 fighter. Numerous special variants tested long-range tankage, different engines and armament, and many experimental fits.

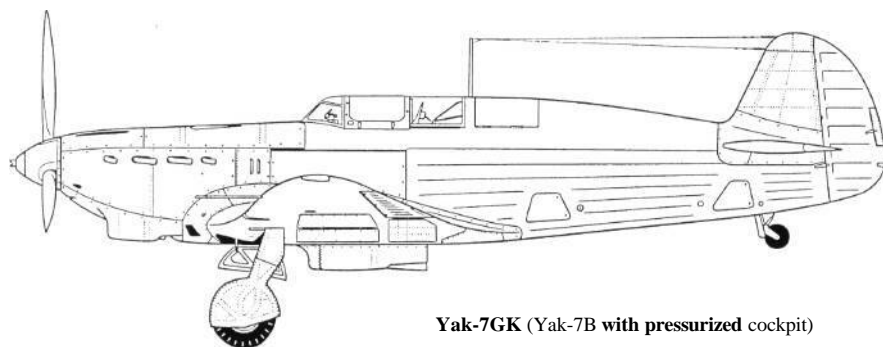
Two series Yak-7B fighters were set aside for testing pressurized cockpits. One, No 08-05, was fitted with a Shcherbakov cockpit completely encased in rubber and with a lightweight canopy giving a much better view than that of the pressurized Polikarpov bi-

planes. The other, with bold white-bordered national insignia, had a hermetically sealed metal (0.8mm AMTs aluminium alloy) cockpit with a heavily framed sliding canopy. In each case the pressurization to 0.2kg/cm^2 (2.85lb/in^2) was by an engine-driven blower. Both were designated Yak-7GK.

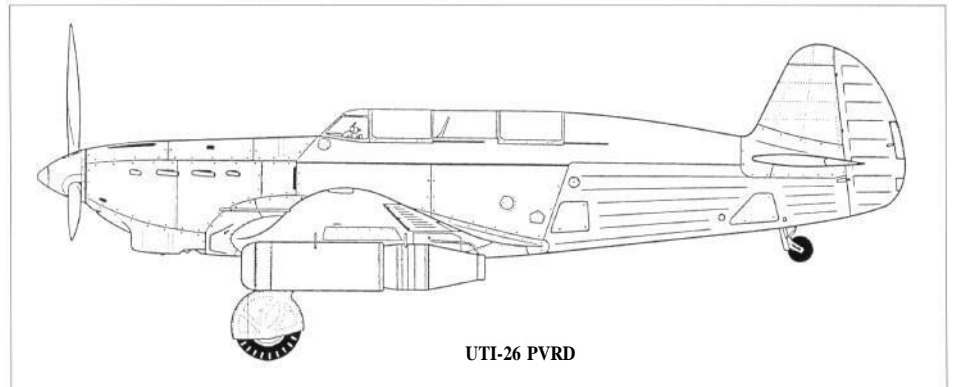
The Yak UTI-26PVRD again repeated research done with a Polikarpov biplane, in this case the I-153/2DM-4. The DM-4 family were the ultimate types of ramjet developed by IA Merkulov. The final DM-4S had a diameter of 500mm (1ft 7 $\frac{7}{8}$ in), a length of 2.3m (7ft 6 $\frac{1}{2}$ in) and weight of 45kg (99lb). The two together burned ordinary petrol (gasoline) from the main aircraft tanks at the rate of 24kg (53 lb) per minute. The test aircraft had been the UTI-26-2, the second prototype two-seater. The rear cockpit was re-equipped for

a test observer, and the main engine was changed to a 1,260hp M-105PF. The pilot could switch fuel to the ramjets and press an ignition button to boost speed from 494km/h (307mph) to 513km/h (319mph) at sea level and to 633km/h (393mph) at 7,300m (23,950ft). The trouble was, though these speeds were a slight improvement over the basic aircraft, for most of the mission the ramjets were dead weight and offered considerable extra drag, reducing speed to 460km/h (286mph) at sea level and 564km/h (339mph) at 6km (19,685ft). The ramjets were first fitted to this aircraft in 1942, but they moved the centre of gravity too far forward and caused fuel leaks because of combustion vibration. The aircraft was put on one side until on 15th May 1944 SNA nokhin began a proper LIL-NKAP test programme. It was judged that the ramjets were not worth having.

Unfortunately, the only known photograph of the Yak-7L is a head-on view. This merely shows that the leading edge of the wing of this aircraft was quite sharp (ie, of small radius) and that the aerofoil profile was almost symmetric except towards the root where, like the wing of the North American P-51 Mustang, it sloped downwards. The letter L in the designation stood for *Laminarnyi* (laminar). As in the Mustang wing, the maximum thickness was at almost 40 per cent chord. Probably influenced by the American fighter, this one-off aircraft is unlikely to have flown before 1943, but the date on the official photograph is unreadable.



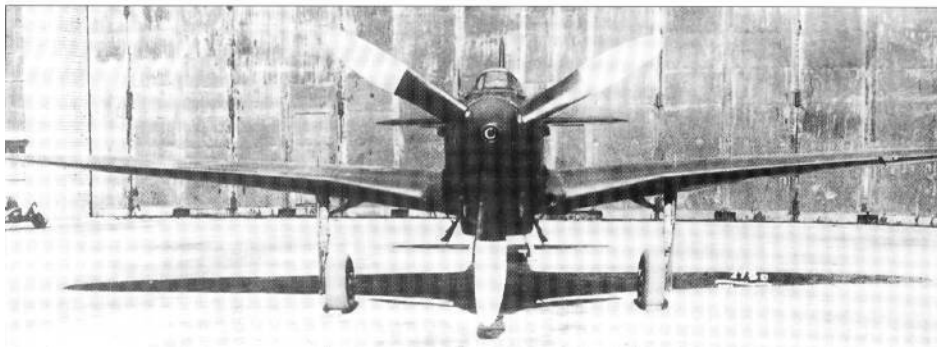
Yak-7GK (Yak-7B with pressurized cockpit)



Photograph on the opposite page:
Yak-7GK.

This page, above and below: **Two views of**
UTI-26PVRD.





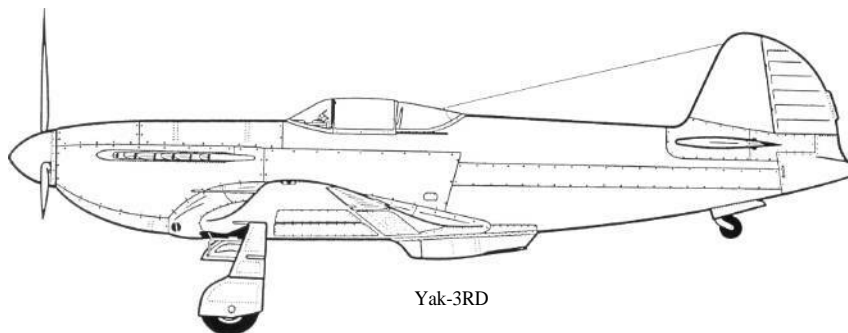
Above: Yak-7L.



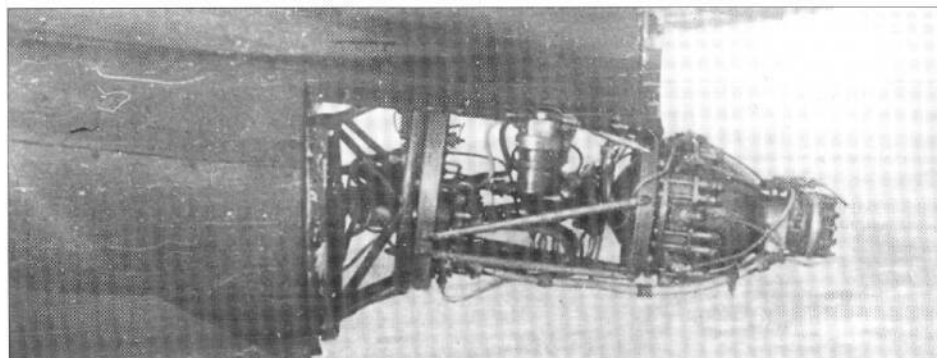
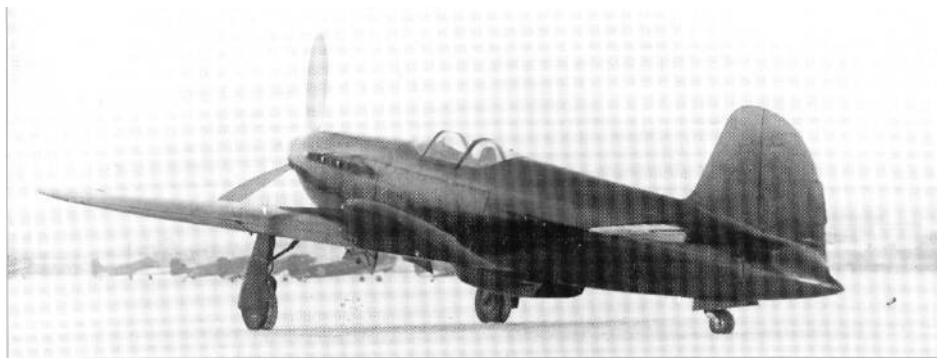
Left: Tail of Yak-9P with side-thrust rocket.

Below centre: Yak-3R.

Bottom: RD-1KhZ engine in Yak-3RD, with the fairing removed.



Yak-3RD



The fastest Yak piston-engine fighter was the Yak-3RD. The Yak-3 was smaller than any other major fighter of the Second World War, and the standard aircraft, powered by the 1,260hp VK-105PF2, had a maximum speed of 646km/h (401 mph) at around 4km (13,120ft). The RD was a normal series aircraft (Saratov-built No 18-20) fitted with an RD-1 rocket engine in the tail. Developed by V P Glushko, this engine was a pilot-controllable single-chamber unit fed by pumps driven by the main engine with 50kg (110lb) of kerosene and 200kg (441 lb) of concentrated nitric acid, supplied from tanks in the wings. Most photographs show this red-painted aircraft with the thrust chamber replaced by a pointed tailcone. The rudder was increased in chord to compensate for loss of the lower portion, and the elevators were cut off at the root and skinned with D1 alloy. OKB test pilot V L Rastorguyev began flight testing on 22nd December 1944. The RD-1 fitted was No 009; this proved to be unreliable, and also failed to give its brochure thrust until the aircraft had climbed to about 6,500m (21,325ft). It was replaced by an RD-1KhZ (No 018), with hypergolic chemical ignition. A level speed of 782km/h (486mph) was then recorded at 7,800m (25,590ft), but malfunctions continued. On 14th May 1945 there was an explosion during a ground start. Flying resumed on 14th August 1945, and on the following day the kerosene pipe fractured. A day later (16th August), after the rocket had been shut down after a maximum-speed run, the aircraft was observed gradually to pitch over and dive into the ground, Rastorguyev being killed. The cause was never established.

The designation Yak-9P was used twice. The first was a variant with a ShVAK cannon (*Pushechnyi*) replacing the usual 12.7mm UBS above the engine. The second use of the designation came in 1946, when it was applied to two of the first Yak-9 fighters built at Factory No 166 at Omsk, Nos 01-03 and 01-04. These were completed with newly designed all-metal wings, because there was no longer a shortage of light alloys. They were exhaustively tested by Yuri A Antipov and VI Ivanov throughout July 1946, and later ten pre-production aircraft were produced at Factory No 153 at Novosibirsk. A surprising amount of effort was put into perfecting an upgraded all-metal Yak-9, because - despite the imminence of jet fighters - no fewer than 772 were built at Factory 153, ending in March 1948. The photo shows the tail of P0415313, with special rudder and elevator instrumentation and a side-thrust rocket attached by a frame to the rear fuselage.

Yakovlev Experimental Jet Fighters

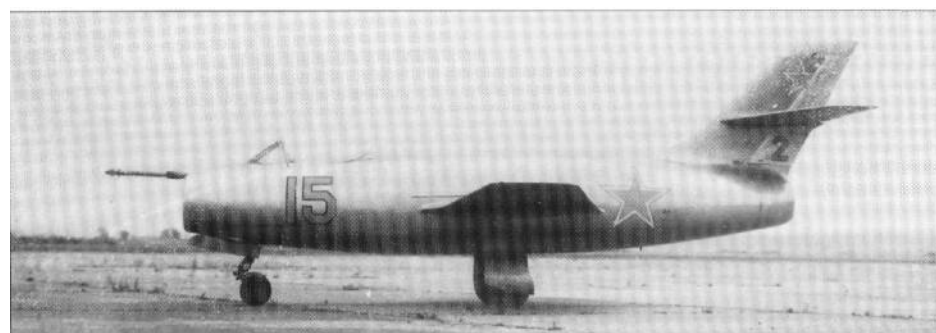
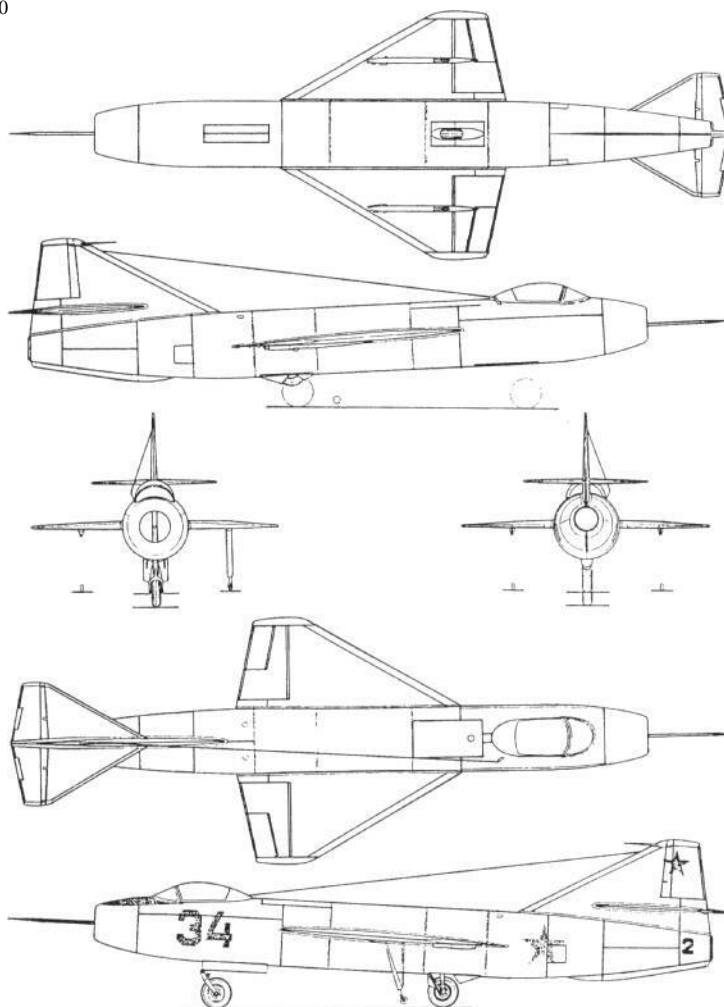
Purpose: To create fighters and interceptors with new and untried features.

Design Bureau: OKB-115 of AS Yakovlev, Moscow.

Yakovlev was one of the two General Constructors who created the first jet aircraft in the Soviet Union (the other was Mikoyan). Yakovlev cheated by, in effect, putting a turbojet into a Yak-3 ! A succession of single-engined jet fighters followed, one of which was the Yak-25 of 1947 (confusingly, Yakovlev later used the same designation for a different aircraft, see later). This achieved the excellent speed of 972km/h (604mph) on the 1,588kg (3,500lb) thrust of a single Rolls-Royce Derwent engine (thus, it was faster than a Gloster Meteor on half as many Derwent engines). The first of two Yak-25 prototypes was modified to evaluate an idea proposed by the DA (Dal'naya Aviatsiya, long-range aviation). Called Burlaki (barge-hauler) this scheme was to arrange for a strategic bomber to tow a jet fighter on the end of a cable until it was deep in enemy airspace and likely to encounter hostile fighters. The friendly fighter pilot would then start his engine and cast off, ready for combat. The first of the two Yak-25 prototypes was accordingly fitted with a long tube projecting ahead of the nose, with a special connector on the end. The two aircraft would take off independently. The bomber would unreel a cable with a special connector on the end, into which the fighter would thrust its probe, as in probe/drogue flight refuelling. It would thus have a free ride to the target area. The idea was eventually rejected: towing the fighter reduced the range of the bomber, the fighter might not have enough range to get home (unless by chance it could find a friendly bomber and hook on), the long tube affected the fighter's agility and, worst of all, the fighter pilot would have to engage the enemy after several hours sitting in a freezing cockpit with no pressurization.

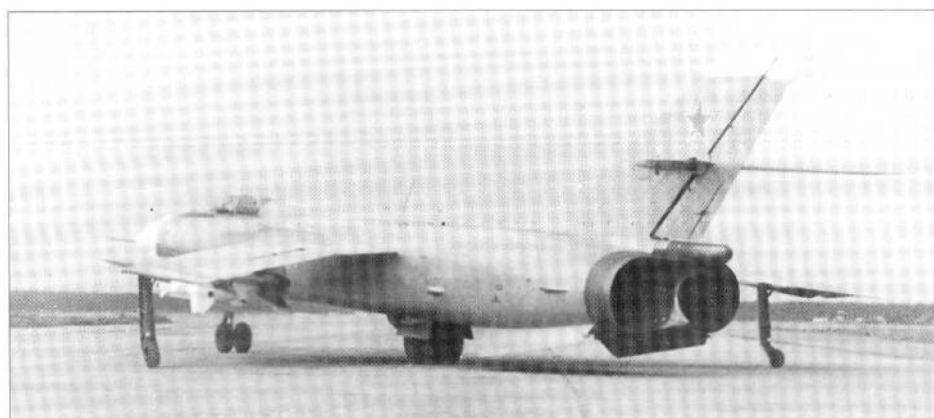
One of the least-known Soviet aircraft was the Yak-1000. The late Jean Alexander was the only Western writer to suggest that this extraordinary creation might have been intended purely for research, and even she repeated the universal belief that its engine was a Lyul'ka AL-5. In fact, instead of that impressive axial engine of 5,000kg (11,023lb) thrust, the strangely numbered Yak-1000 had a Rolls-Royce Derwent of less than one-third as much thrust. Designed in 1948-49, this aircraft was notable for having a wing and horizontal

Yak-1000



Centre: Yak-1000.

Bottom: Yak-25E Burlaki.



tail of startlingly short span (wing span was a mere 4.52m, 14ft 10in), almost of delta form and with a thickness/chord ratio nowhere greater than 4.5 per cent and only 3.4 per cent at the wing root. Behind the rear spar the entire wing comprised a powerful slotted flap, the outer portion of which incorporated a rectangular aileron. The tailplane was fixed half-way up the fin, which again was a low-aspect-ratio delta fitted with a small rudder at the top. The long tube-like fuselage had the air inlet in the nose, the air duct being immediately bifurcated to pass either side of the cockpit, which was pressurized and had an ejection-seat. The inevitably limited supply of 597 litres (131 Imperial gallons) of fuel was housed in one tank ahead of the engine and another round the jetpipe. The only way to arrange the landing gear was to have a nose-wheel and single (not twin, as commonly thought) mainwheel on the centreline and small stabilizing wheels under the wings. Flight controls were manual, the flaps, landing gear and other services were worked pneumatically, and the structure was light alloy except for the central wing spar which was high-tensile SOKhGSNA steel. Only one flight article was built, the objective being a speed in level flight of 1,750km/h (1,087mph, Mach 1.65). Taxi testing began in 1951, and as soon as high speeds were reached the Yak-1000 exhibited such dangerous instability that no attempt was made to fly it.

In the jet era there is no doubt that Yakovlev's most important aircraft were the incredibly varied families of tactical twin-jets with basic designations from Yak-25 (the second time this designation was used) to Yak-28. Some of the sub-variants were experimental in nature. One was the Yak-27V, V almost certainly standing for Vysotnyi, high altitude, because it was specifically intended for high-altitude interceptions. This was a single flight article, which had originally been constructed as the Yak-121, the prototype for the Yak-27 family, with callsign Red 55. To turn it into the Yak-27V it was converted into a single-seater, and a Dushkin S-155 rocket engine was installed in the rear fuselage, replacing the braking parachute. The S-155 had a complicated propellant supply and control system, because it combined petrol (gasoline) fuel with a mixture of RFNA (red fuming nitric acid) and HTP (high-test hydrogen peroxide) oxidant, plus a nitrogen purging system to avoid explosions. Brochure thrust of the S-155 was 1,300kg (2,866lb) at sea level, rising to 1,550kg (3,417lb) at 12km (39,370ft). Airframe modifications included adding an extended and drooped outer leading edge to the wing (though the chordwise extension

Top: Yak-27V.

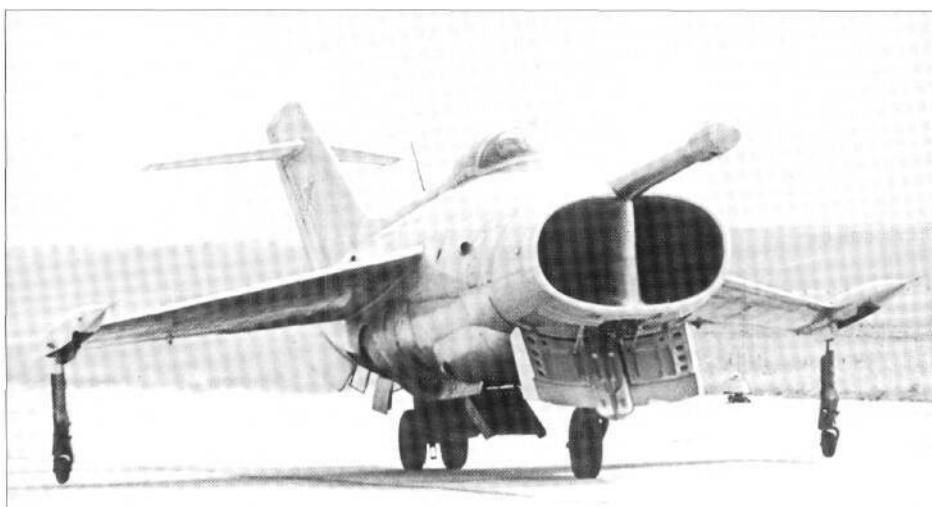
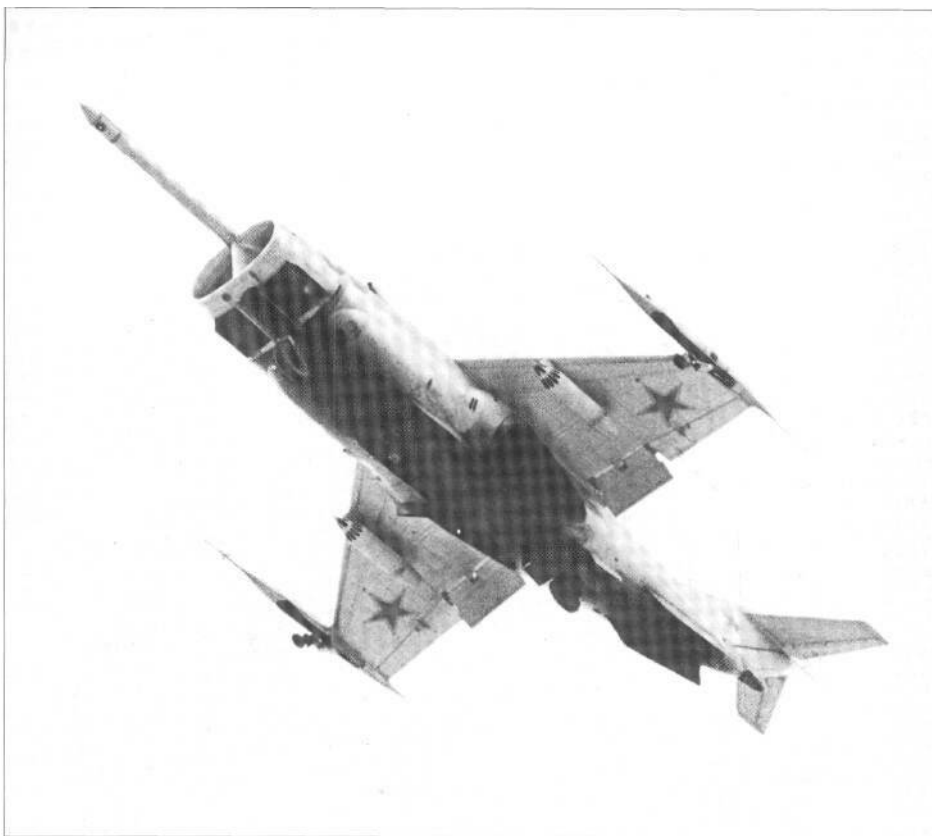
Three views of Yak-28-64 (two R-8T and two R-3S).

was not as large as in the later Yak-28 family), converting the horizontal tail into one-piece stabilizers, fitting the rearranged tankage, and replacing the nose radar by a metal nose. The two NR-30 cannon were retained. The RD-9AK engines were replaced by the specially developed RD-9AKE, with a combustion chamber and fuel system specially tailored for high altitudes; thrust was unchanged at 2,800kg (6,173lb). Yakovlev hired VGMukhin to join the OKB's large test-pilot team because he had tested the mixed-power Mikoyan Ye-50 with a similar S-155 rocket engine. He opened the test-flying programme on 26th April 1956. Service ceiling of the Yak-27V was found to be 23.5km (77,100ft), and level speed above 14km (45,900ft) about 1,913km/h (1,189mph, Mach 1.8).

Yakovlev had been fortunate in having members of this prolific twin-jet family in series production at four large factories, No 99 at Ulan-Ude, No 125 at Irkutsk, No 153 at Novosibirsk and No 292 at Saratov. Unfortunately, by 1964 no new orders were being placed and the end was in sight. In that year, right at the end of the development of the family, Yakovlev tried to prolong its life by undertaking a major redesign. He sent his son Sergei to study the variable inlets and engine installation of the rival Su-15, and he also carefully studied the MiG Ye-155, the prototypes for the MiG-25. All these were faster than any Yaks, and they had engines in the fuselage. Accordingly, whilst keeping as many parts unchanged as possible, the Yak-28-64 was created, and this single flight article, call sign Red 64, began flight testing in 1966. The engines remained the R-11AF2-300, as used in most Yak-28s (and also, as the R-11F2-300, in many MiG-21s), with dry and afterburning ratings of 3,950kg (8,708lb) and 6,120kg (13,492lb) respectively. Instead of being hung under the wings they were close together in the rear fuselage, fed by vertical two-dimensional inlets with variable profile and area. Drop tanks could be hung under the inlet ducts on the flanks of the broad fuselage. This wide fuselage added almost a metre to the span (from 11.64m, 38ft 2¹/₂in, to 12.5m, 41ft), and removing the engines from the wings enabled the ailerons to be extended inboard to meet the flaps. Armament comprised four guided missiles, two from the K-8 family (typically an R-8M and an R-8T) and two R-3S copies of the American Sidewinder. To Yakovlev's enormous disappointment, the huge sum spent by the OKB in developing this aircraft was wasted. Its performance was if anything inferior to that of the Yak-28P, and handling was unsatisfactory to the point of being unacceptable.

Top: Yak-36 c/n 38, with rocket pods.

Two views of Yak-36 experimental VTOL aircraft.



In 1960 Yakovlev watched the Short SC.1 cavorting at Farnborough and became captivated by the concept of SWP (Russian for VTOL, vertical take-off and landing). Though he received funding for various impressive Yak-33 studies in which batteries of lift jets would have been installed in a supersonic attack aircraft, he quickly decided to build a simple test-bed in the class of the Hawker P.1127, with vectored nozzles. No turbofan existed which could readily be fitted with four nozzles, as in the British aircraft, but, after funding was provided by the MAP and the propulsion institute CIAM, K Khachaturov in the Tumanskii engine bureau developed the R-27 fighter turbojet into the R-27V-300 with a nozzle able to be vectored through a total angle of 100°. Rated initially at 6,350kg (14,000lb), this engine had a diameter of 1,060mm (3ft 5½in) and so it was a practical proposition to fit two close side-by-side in a small fuselage. Of course, the engines had to be handed, because the rotating final nozzle had to be on the outboard side. This was the basis for the Yak-36 research aircraft, intended to explore what could be done to perfect the handling of a jet-lift aeroplane able to hover. To minimise weight, the rest of the aircraft was kept as small as possible. The engines were installed in the bottom of the fuselage with nozzles at the centre of gravity, fed directly by nose inlets. The single-seat cockpit, with side-hinged canopy and later fitted with a seat which was arranged to eject automatically in any life-threatening situation, was directly above the engines. The small wing, tapered on the leading edge and with -5° anhedral, was fitted with slotted flaps and powered ailerons. Behind the engines the fuselage quickly tapered to a tailcone, and carried a vertical tail swept sharply back to place the swept horizontal tail, mounted

near the top, as far back as possible. The tailplane was fixed, and the elevators and rudder were fully powered. For control at low airspeeds air bled from the engines was blasted through downward-pointing reaction-control nozzles on the wingtips and under the tailcone and on the tip of a long tubular boom projecting ahead of the nose. The nose and tail jets had twin inclined nozzles which were controllable individually to give authority in yaw as well as in pitch. The landing gear was a simple four-point arrangement, with wingtip stabilizing wheels, of the kind seen on many earlier Yak aircraft. The OKB factory built a static-test airframe and three flight articles, Numbered 36, 37 and 38. Tunnel testing at CAHI (TsAGI) began in autumn 1962, LII pilot Yu A Garnayev made the first outdoor tethered flight on 9th January 1963 and Valentin Mukhin began free hovering on 27th September 1964. On 7th February 1966 No 38 took off vertically, accelerated to wingborne flight and then made a fast landing with nozzles at 0°. On 24th March 1966 a complete transition was accomplished, with a VTO followed by a high-speed pass followed by a VL. The LII stated that maximum speed was about 1,000km/h, while the OKB claimed U00km/h (683mph). Both Nos 37 and 38 were flown to Domodedovo for Aviation Day on 9th July 1967. Later brief trials were flown from the helicopter cruiser Moskva.

From the Yak-36 were derived the Yak-36M, Yak-38, Yak-38U and Yak-38M, all of which saw service with the A-VMF (Soviet naval aviation). This inspired the OKB to produce the obvious next-generation aircraft, with fully supersonic performance. A design contract was received in 1975. Yak called the project Izdeliye (Product) 48, and it received the Service designation Yak-41. Seldom had there been so many possible aircraft configura-

tions, but at least this time funds were made available for the necessary main engine. With much help from CIAM, this was created as the R-79V-300 by the Soyuz bureau, led after Tumanskii's death in 1973 by Oleg N Favorskii, and from 1987 by Vasili K Kobchenko. The R-79 was a two-shaft turbofan with a bypass ratio of 1.0, with a neat augmentor and a fully variable final nozzle joined by three wedge rings which, when rotated, could vector the nozzle through 63° for STO (short take-off) or through 95° for VTO (vertical take-off). Ratings were 11,000kg (24,250lb) dry, 15,500kg (34,171 lb) with maximum augmentation and 14,000kg (30,864 lb) with maximum augmentation combined with maximum airbleed for aircraft control. The reason the nozzle vectored through 95° was because, immediately behind the cockpit, the Yak-41 had two Rybinsk (Novikov) RD-41 lift jets in tandem whose mean inclination was 85°. Their nozzles had limited vectoring but, at this mean position, in hovering flight they blasted down and back so the main engine had to balance the longitudinal component by blasting down and forwards. Sea-level thrust of each RD-41 was 4,100kg (9,040lb); thus, total jet lift was about 22,200kg (48,942 lb), but in fact the Yak-41 was not designed to fly at anything like this weight. Compared with its predecessors it was far more sharp-edged and angular. The wing had a thickness/chord ratio of 4.0 per cent, and leading-edge taper of 40°. The outer wings, which in fact had slight sweepback on the trailing edge, folded for stowage on aircraft carriers. The leading edge had a large curved root extension, outboard of which was a powerful droop flap. On the trailing edge were plain flaps and powered ailerons. The wing had -4° anhedral, and was mounted on top of a wide box-like mid-fuselage, from which projected a slim nose and cock-



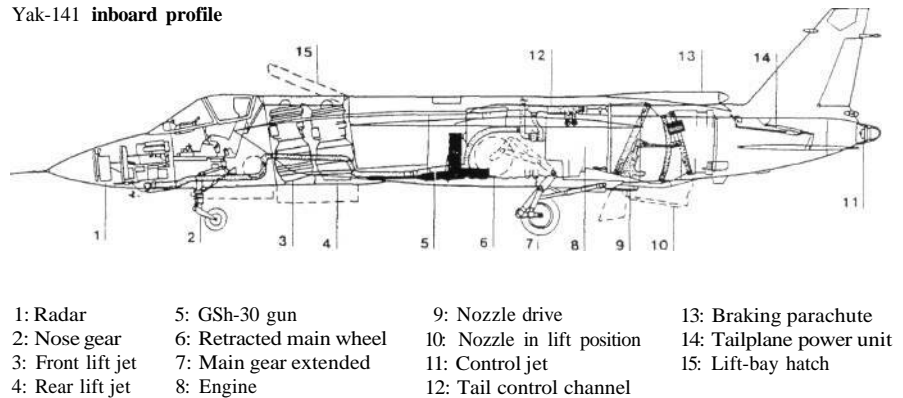
pit ahead of the large variable wedge inlets which led to ducts which, behind the lift engines, curved together to feed the main engine. The latter's nozzle was as far forward as possible. Beside it on each side was a narrow but deep beam carrying a powered tailplane and a slightly outward-sloping fin with a small rudder. Unlike most military Yak jets the Yak-41 had a conventional tricycle landing gear. In hovering flight recirculation was minimised by the open lift-bay doors, a hinged transverse dam across the fuselage ahead of the main gears, a large almost square door hydraulically forced down ahead of the main engine nozzle, and a long horizontal strake along the sharp bottom edge of the fuselage on each side. Fuselage tanks held 5,500 litres (1,210 Imperial gallons) of fuel, and a 2,000 litre (440 Imperial gallon) conformal tank could be scabbled under the fuselage. Flight and engine controls were eventually interlinked and digital, the hovering controls comprising twin tandem jets at the wingtips and a laterally swivelling nozzle under the nose (which replaced yaw valves at the tip of each tailcone). An interlinked system provided automatic firing of the K-36LV seat in any dangerous flight situation. In 1985 it was recognized that such a complex and costly aircraft ought to have multi-role capability, and the new designation Yak-41 M was issued for an aircraft with extremely comprehensive avionics and weapons. Equipment included a 30mm gun and up to 2.6 tonnes (5,732 lb) of ordnance on four underwing pylons. The OKB received funding for a static/fatigue test aircraft called 48-0, a powerplant test-bed (48-1) and two flight articles, 48-2 (callsign 75) and 48-3 (callsign 77). Andrei A Sinitsyn flew '75' as a conventional aircraft at Zhukovskii on 9th March 1987. He first hovered '77' on 29th December 1989, and in this aircraft he made the first complete transition on 13th June 1990. Maximum speed was 1,850km/h (1,150mph, Mach 1.74) and rate of climb 15km (49,213ft) per minute. In April 1991 Sinitsyn set 12 FAI class records for rapid climb with various loads, and as the true designation was classified the FAI were told the aircraft was the 'Yak-141'. In September 1992 48-2 was flown to the Farnborough airshow, its side number 75 being replaced by '141'. A year earlier the CIS Navy had terminated the whole Yak-41 M programme, and the appearance in the West was a fruitless last attempt to find a partner to continue the world's only programme at that time for a supersonic jet-lift aircraft. Apart from publicity, all today's Yakovlev Corporation finally received for all this work was a limited contract to assist Lockheed Martin's Joint Strike Fighter.

Opposite: Yak-41 M with Yak-38M.

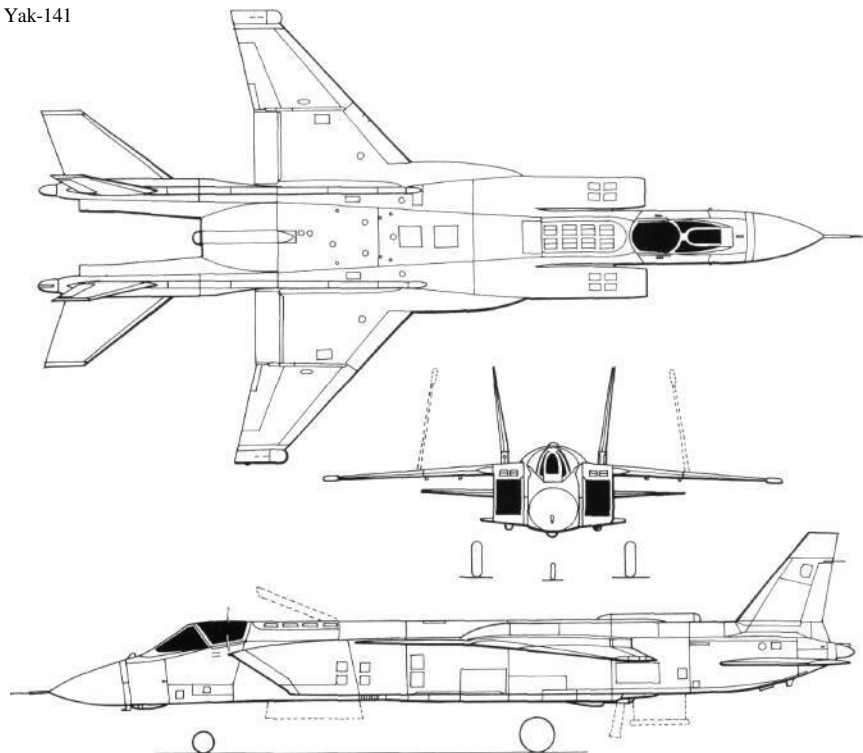
This page, top: Yak-141, No 75 on carrier.



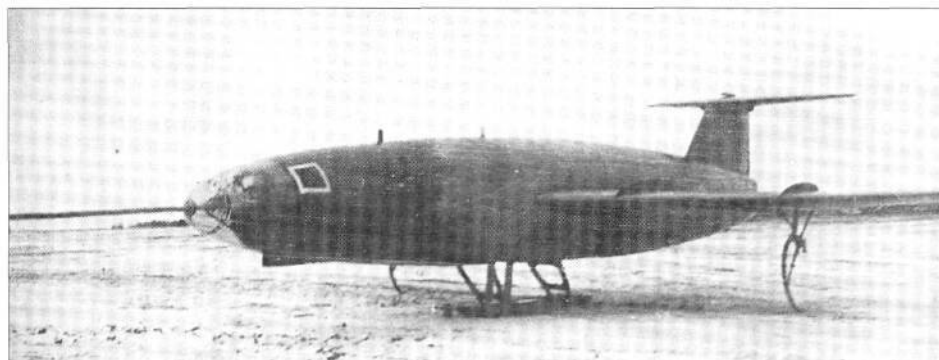
Yak-141 inboard profile



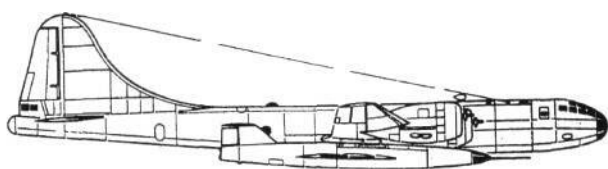
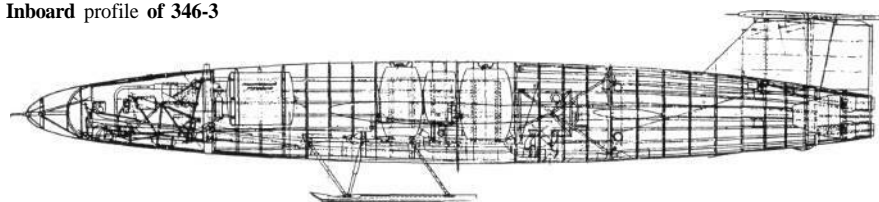
Yak-141



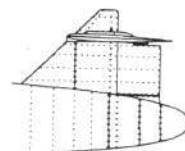
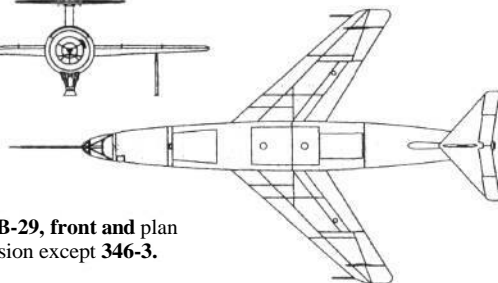
Type 346



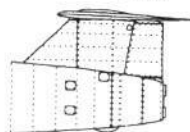
Inboard profile of 346-3



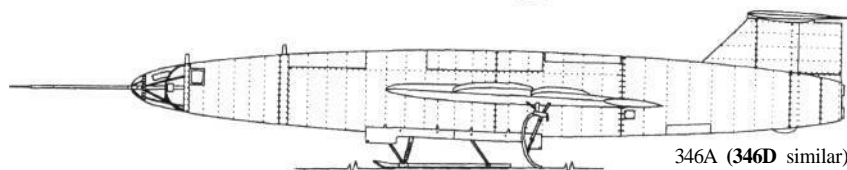
346A carried by B-29, front and plan views of any version except 346-3.



346P



346-3



346A (346D similar)

Purpose: To continue German development of a supersonic rocket aircraft.

Design Bureau: OKB-2 at Podberez'ye, lead designer Hans Rosing, in October 1948 replaced by SM Alekseyev.

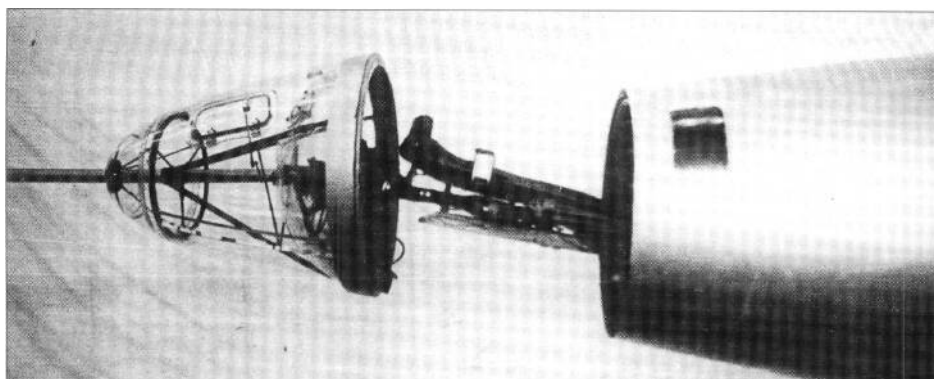
On 22nd October 1946 a second group of German design engineers was formed at Podberez'ye to continue development of the DFS-346 supersonic research aircraft originally designed at the DPS (German institute for gliding) at Griesheim near Darmstadt. Models, some made in Germany, were tested in CAHI (TsAGI) tunnels, and a North American B-25 was fitted with a mock-up nose to test the cockpit jettison system. In 1947 (date not discovered) the 346P (P from planer, glider) unpowered version was taken to the test airfield at Tyoplyi Stan and dropped from under the starboard wing of a captured B-29 (previously USAAF 42-6256). Amazingly, the 346P was flown not by a Russian but by Wolfgang Ziese, who had previously been chief test pilot of the German Siebel Flugzeugwerke. He had no problems, and brought the glider to a normal landing. In 1948 (date not discovered) the 346-1 high-speed glider version, also known as the 346A, was released from a Tu-4 (B-29 copy) and similarly flown by Ziese to a normal landing. On 30th September 1949 the 346-2, also known as the 346D, was dropped from the B-29 and flown as a glider by Ziese even though it was fitted with rocket propulsion. No propellant was loaded, so the aircraft was much lighter than it would have been with full tanks. Despite this Ziese landed too fast and, more seriously, the landing skid failed to extend, resulting in serious damage to both the aircraft and pilot. This aircraft was repaired, and in October 1950 LII pilot PI Kasmin flew it at Lukhovitsy, according to the record making a normal take-off from the runway despite having only skid landing gear. Ziese recovered, and on 13th August 1951 he flew the final aircraft of this programme, the 346-3, and fired the engines. He flew again on 2nd September, but on the third flight, on 14th September, he lost control. He managed to separate the jettisonable nose from the tumbling aircraft, but this ended the programme. Later versions were abandoned. Various 346 parts were donated to the Moscow Aviation Institute.

Like its American counterpart the Bell XS-1, the 346 was an almost perfectly streamlined body with mid-mounted wings. Unlike the XS-1, it had a prone pilot position, skid landing gear, swept wings and an extremely squat vertical tail with the tailplane on top. Construction was almost wholly flush-riveted light alloy. The wings had NACA-012 profile (12 per cent thick) and a sweep angle of 45° at the 1/4-chord line. Each wing had two shallow fences from the

leading edge to the plain flap. At the tips were inverse-tapered two-section ailerons, the inner sections being locked at high airspeeds. The elevators were similar in principle. On the 346P the tailplane, with 14-chord sweep of 35°, was fixed and surmounted by a small fixed fin. On the 346-2 and -3 the tailplane was driven by an irreversible power unit over the range -2° to $+2^{\circ}$. The fuselage was of circular section, with the entire nose arranged to slide forward for pilot entry and to jettison in emergency. The pilot lay on his stomach looking ahead through the Plexiglas noscap, through which protruded the long instrumentation boom. Bottled gas pressure operated the flaps and retracted the skid into a ventral recess which, except for the 346P, could be faired over with twin doors. Under the tail was a small steel bumper. Unlike its predecessors, the 346-3 could be fitted with a curved skid with a levered shock strut hinged under each outer wing. These were jettisoned after take-off. The propulsion system was the Walter HWK 109-509C, called ZhRD-109-510 in the USSR. This had two superimposed thrust chambers, one which fired continuously whenever the system was in operation, and a larger chamber used only for take-off or for brief periods when maximum thrust was needed. The cruise chamber was rated at sea level at 300kg (661 lb), and the main chamber at 1,700kg (3,748 lb). The combined thrust at high altitude was about 2,250kg (4,960 lb). Immediately behind the jettisonable nose section was a tank of concentrated hydrogen peroxide (called T-Stoff in Germany) while in the centre fuselage were interconnected tanks of methanol/hydrazine hydrate (C-Stoff). German turbopumps running on calcium permanganate fed the highly reactive fluids to the thrust chambers, where ignition was hypergolic (instantaneous).

Probably as much effort went into the 346 programme as the Americans expended on the XS-1 or D-558-II, but there was no comparison in what the programmes achieved. There is no obvious reason why these challenging aircraft, designed for Mach 2, should simply have been abandoned without even reaching Mach 1.

| Dimensions | | |
|---|---------------------|--------------------|
| Span | 9m | 29 ft 6 1/2 in |
| Length | | |
| (346-3, nose to engine nozzles) | 13.447 m | 44 ft 11 in |
| (instrument boom to tailplanes) | 15.987 m | 52 ft 3 1/4 in |
| Wing area (net) | 14.87m ² | 160ft ² |
| Weights (346-3) | | |
| Empty | 3,180kg | 7,011 lb |
| Propellants | 1,900kg | 4,189 lb |
| Loaded | 5,230kg | 11,530 lb |
| Performance | | |
| Max speed, intended | 2,127 km/h | 1,322 mph (Mach 2) |
| in a 2 min full-power burn at high altitude | | |
| No other data. | | |



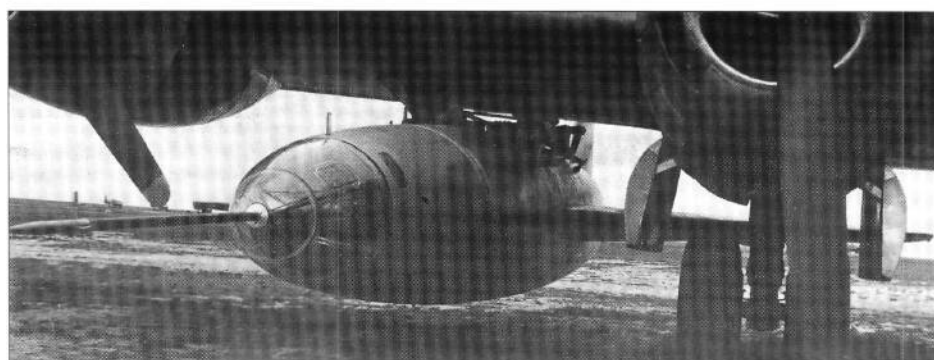
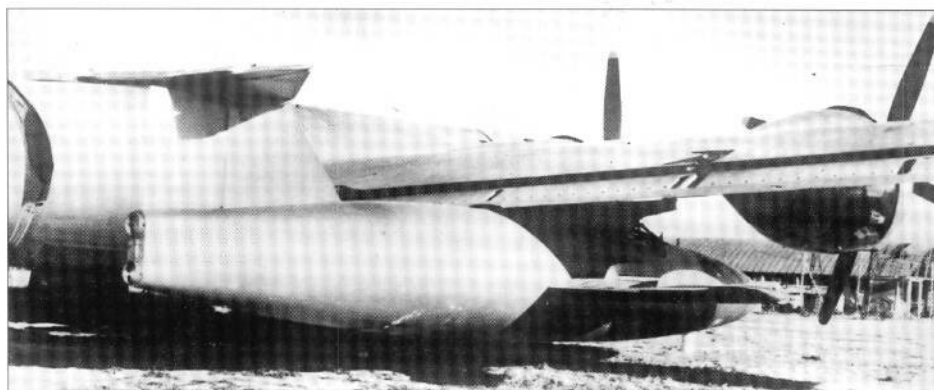
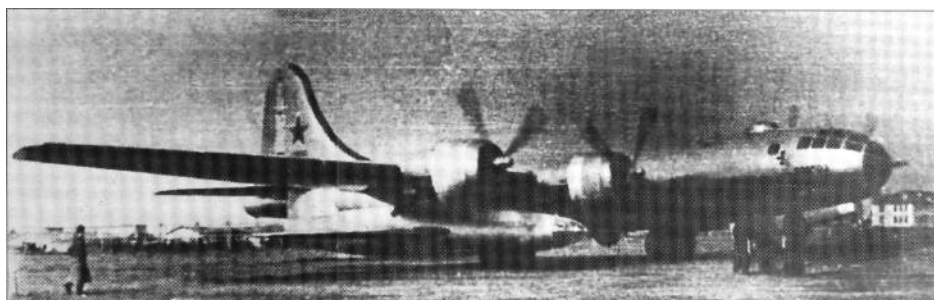
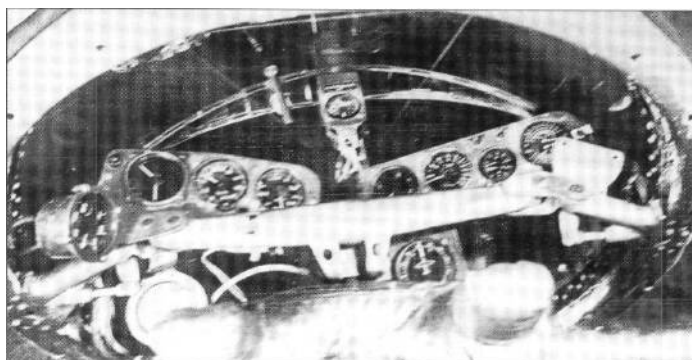
Opposite page, top: B-25 with 346 cockpit capsule.

Opposite page: 346P.

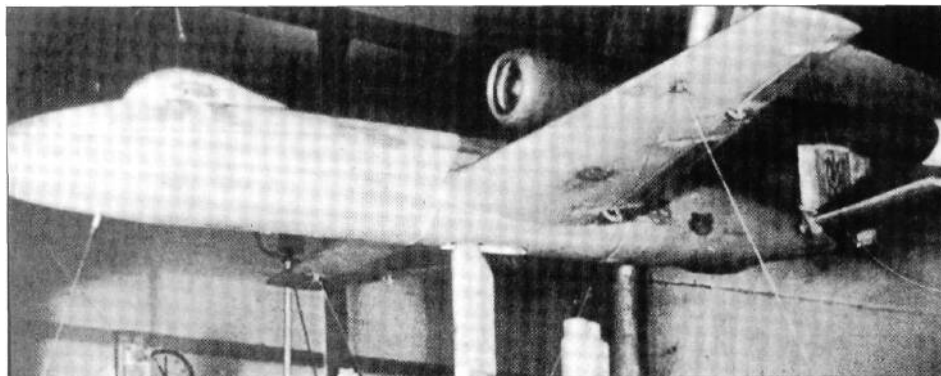
Above: 346-2 (346D) nose open showing pilot couch.

Right: Looking down into open nose.

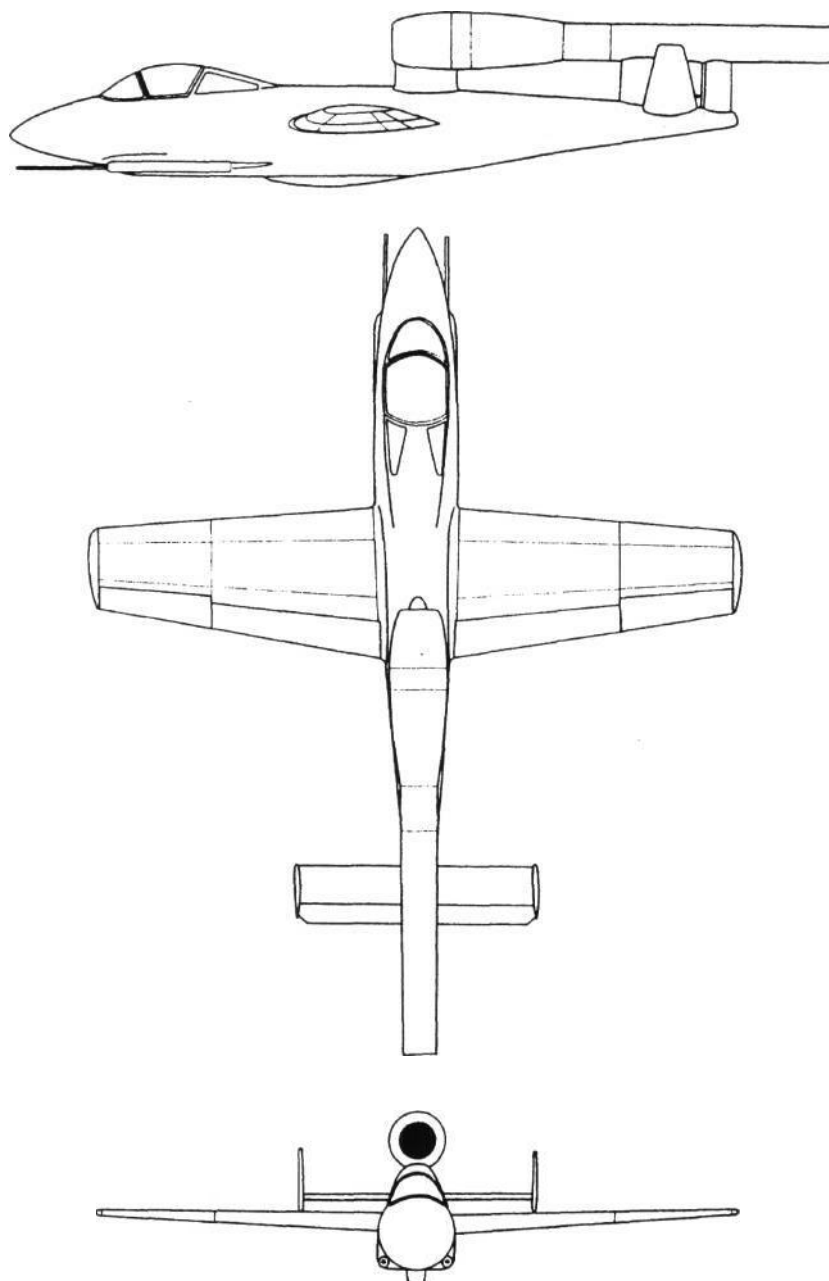
Below: Three views of 346-2 on B-29.



EF 126



EF126



Purpose: Experimental ground-attack aircraft.

Design Bureau: OKB-1, formed of German engineers led by Dipl-Ing Brunolf Baade, at Podberez'ye.

In November 1944 beleaguered German design teams worked round the clock with 'crash' programmes intended to meet an RLM (Reich Air Ministry) specification for a miniature fighter designed to produce effective last-ditch defence. At the Junkers company the most important proposal was the **EF** (Entwicklungs Flugzeug, development aircraft) 126, code-named Elli. This was to be a small fighter powered by one of the Argus pulsejets already in mass-production for the Fi 103 flying bomb. Messerschmitt already had such an aircraft, the Me 328, powered by two of these units, testing of which showed that the violent vibration of the engines had a severe effect on the airframe and pilot. The **EF 126** was smaller, almost a copy of the Fi 103 Reichenberg, the piloted version of the flying bomb. In late 1944 it was decided that, because of poor pulsejet performance at altitude, the mission should be changed to ground attack. Despite frantic work little hardware appeared before Germany collapsed. A German three-view has been found bearing the date 9th May 1945, the day after the final surrender ! Moreover, the span quoted (6.35m) is different from that given in other early-May documents, showing that the design was still fluid. Indicative of the panic environment, the data panel on this drawing gives the length as 8.9m while the drawing itself gives the same length as that below ! Despite this, and the primitive nature of the project, the **EF 126** was snapped up by the Russians. In October 1945 the Soviet MAP (ministry of aviation industry) organised the Junkers workers into an EF 126 cell at Dessau, headed by Prof Brunolf Baade. The intention was that this group would be moved to the USSR, but the EF 126 cell remained at Dessau while the much larger group working on jet bombers formed OKB-1 at Podberez'ye (see next entries). By January 1946 an engineering mockup had been built and parts for five aircraft produced. The EF 126 VI (first prototype) was ready in May 1946, and flight testing opened on 12th May with the VI towed as a glider behind a Ju 88. The pilot was Mathis and the tug pilot Schreiber. The **EF 126** was cast off and made a normal landing. However, on 21st May Mathis was killed, after he had misjudged his glide approach, bounced hard on the rear skid, rolled to the right and cartwheeled. MAP granted permission for the resumption of test-

Top.- EF 126 in wind tunnel.

ing in July, after modification of the leading edge. The new pilot, Huelge, was pleased by the modified aircraft, which by this time was making rocket take-offs from a ramp. The new pulsejet engine caused problems, take-off rockets ran out, and an MAP commission headed by A S Yakovlev rejected the EF 126 as an operational vehicle because of 'weak armament, absence of armour and insufficient fuel...' It gave permission for work to continue to help develop the engine, ramp launch and skid landing. In September 1946 V2, V3 and V4 were sent to LII (today called Zhukovskii), supported by 18 specialists headed by Ing. Bessel. Further delays were caused by design changes, but gliding flights after a tow by Ju 88 resumed with V5 on 16th March 1947. The MAP directive that three aircraft should take part in the Tushino display came to nothing, but by the end of the year V3 and V5 had made 12 short flights, five of them under power. The Jumo 226 engine made 44 test flights slung under a Ju 88, but predictably the whole programme was cancelled at the start of 1948.

The EF126 resembled the Fi105 flying bomb in many respects, except that instead of a warhead the nose contained the cockpit, the wings had 3° dihedral (and like some flying bombs were made of wood) and housed fuel tanks, and skid landing gear was fitted (the original Junkers drawings showed retractable tricycle gear). One drawing shows a single large retractable skid, but the prototypes had two small skids in tandem. The wing was fitted with pneumatically driven flaps, and a braking parachute was housed in the rear fuselage. The original intention was to have twin fins. EF 126 VI was fitted with the standard flying-bomb engine, the Argus 109-014 rated at 350kg (772 lb) thrust at sea level. All subsequent aircraft had the 109-044, which Junkers took over as the Jumo 226, rated at 500kg (1,102 lb). Despite prolonged testing this suffered from difficult ignition, poor combustion and dangerous fires. Three tanks housed 1,320 litres (290 Imperial gallons) of fuel, fed by air pressure. Ramp take-off was by two solid motors each with an impulse of 12,000kg-seconds. Arma-

ment comprised two MG 151/20, each with 180 rounds, plus an underwing load of two AB 250 containers, each housing 108 SD2 'butterfly bombs', or 12 Panzerblitz hollow-charge bomblets.

A good idea for a last-ditch weapon was unlikely to survive in the post-war era of rapid technical development.

Dimensions (V5)

| | | |
|-----------------|--------------------|---------------------|
| Span | 6.65m | 21 ft 9% in |
| Length | 8.5m | 27 ft 10% in |
| (fuselage only) | 7.8m | 25 ft 7 in |
| Wing area | 8.9 m ² | 95.8ft ² |

Weights

| | | |
|--------|----------|----------|
| Empty | 1,100kg | 2,425 lb |
| Loaded | 2,800 kg | 6,173 lb |

Performance

| | | |
|-----------------------|----------|-------------|
| Maximum speed (clean) | 780km/h | 485 mph |
| (external load) | 680 km/h | 423 mph |
| Range/endurance | | |
| (full power) 300 km | 23min | (186 miles) |
| (60% power) 350 km | 45min | (217 miles) |

EF 131

Purpose: To improve a German design for a jet bomber.

Design Bureau: OKB-1, formed of German engineers led by Dipl-Ing Brunolf Baade, at Podberezye.

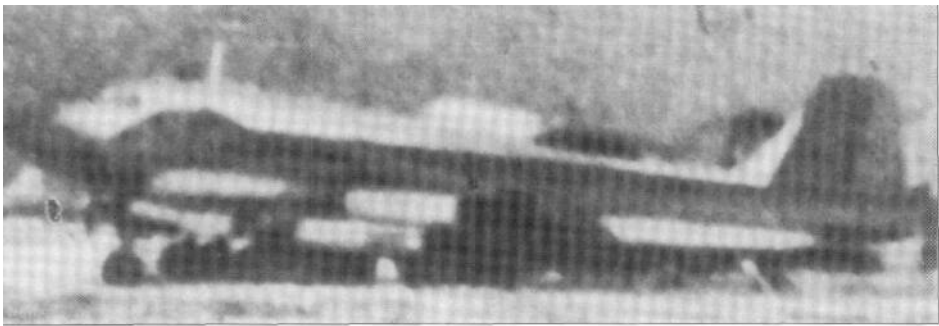
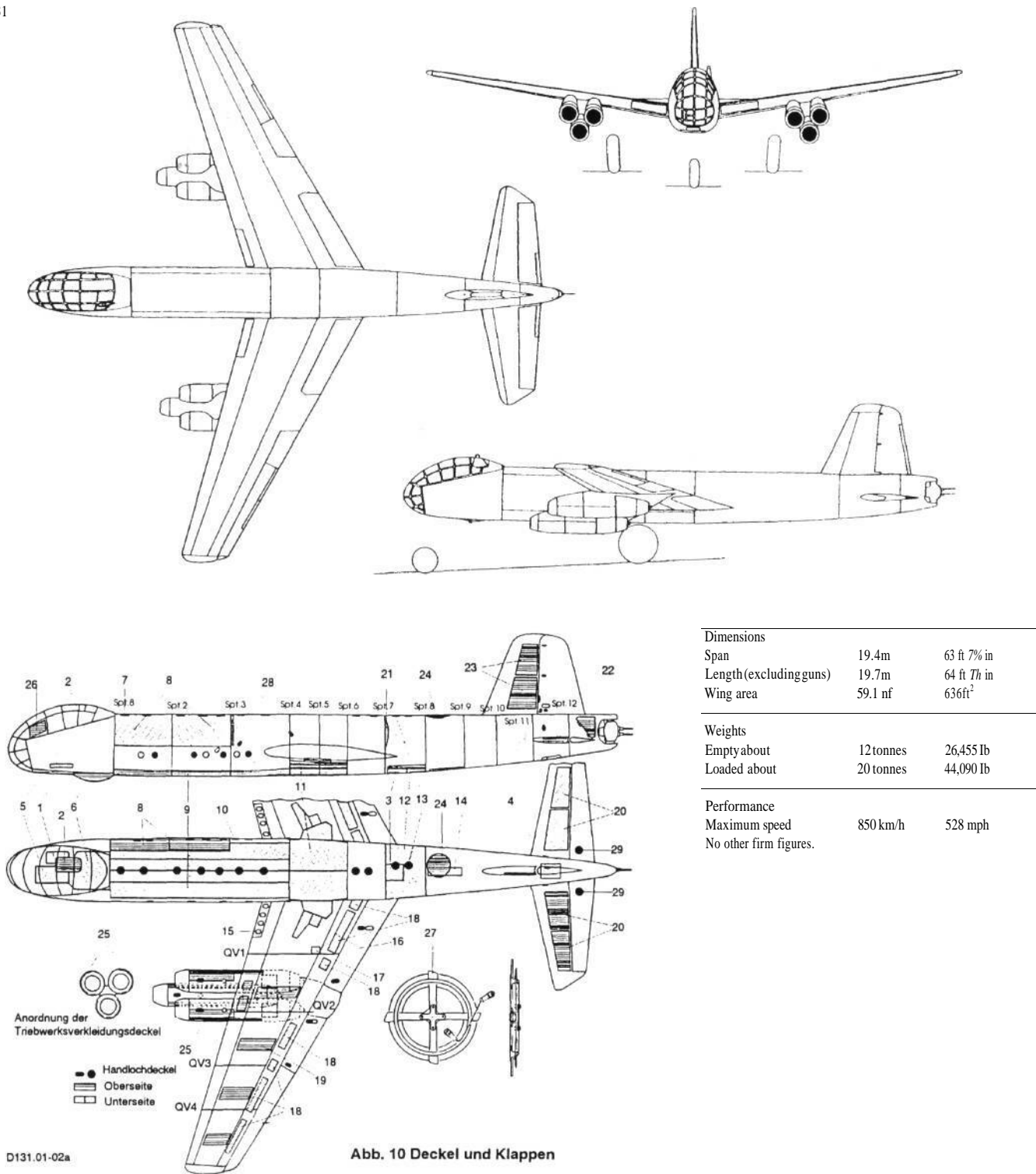
From late 1944 the Red Army overran many sites where German aircraft engineers had been working on jet aircraft and engines. The largest group had been in the employ of the vast Junkers Flugzeug und Motorenwerke in the Dessau area and at Brandis near Leipzig. At Brandis the principal project had been the Ju 287 jet bomber. Having flown the Ju 287 VI (a primitive proof-of-concept vehicle incorporating parts of other aircraft) on 16th August 1944, work had gone ahead rapidly on the definitive Ju 287 V2, to be powered by two triple engine pods, but the Soviet forces overran Brandis airfield before this could fly. This work was clearly of intense interest, and with the aid of a large team of ex-Junkers engineers, who were prisoners, the programme was continued with all possible speed. The Ju 287 V2 stage was skipped, and parts of this aircraft were used to speed the construction of the next-generation EF 131 (Entwicklungs Flugzeug, meaning research aircraft). This was built at Dessau, dismantled, and, together with many of the German engineers and test pilots, taken by train to Moscow. As explained in the next entry, they formed OKB-1. Final assembly took place at the test

airfield then called Stakhanovo (today at LII Zhukovskii) where on or about 23rd May 1947 it was briefly flight tested by Flugkapitan Paul Julge. According to legend, he was never allowed enough fuel to reach 'the West'. By this time more advanced aircraft and engines were being developed in the Soviet Union, and the EF 131 spent long periods on the ground. MAP Directive 207ss of 15th April 1947 had demanded that 'two prototype EF-131 with six RD-10 engines to take part in the August Tushino display...' but this was impossible to achieve. Eventually the first aircraft was again made airworthy and flown to Moscow's other experimental airfield, Tyopli Stan. On 21st June 1948 the order was given to stop EF 131 work. This was because it had been overtaken by the much better Type 140.

The EF 131 was an impressive-looking jet bomber, characterised by its swept-forward wing. To postpone the rapid increase in drag as Mach number exceeds about 0.75 German aerodynamicists had from 1935 studied wings swept either backwards or forwards. The FSW (forward-swept wing) appeared to offer important aeroelastic advantages, but because such wings diverge under increasing aerodynamic load they are structurally very difficult. The Ju 287 VI avoided this problem by being a slow-speed aircraft, but the problem was met head-on by the 131 and 140, and also by the Tsybin LL-3 (which see). The first

structurally satisfactory FSW was that of the Grumman X-29, almost 40 years later, and a more advanced FSW is seen in today's Sukhoi S-37 (which see). Thus, the FSW of the EF 131 can be seen to have been an enormous challenge. Aerodynamically it was directly derived from that of the wartime Ju 287, with considerable dihedral and a leading edge swept forward at 19° 50'. It was fitted with slats at the wing roots, slotted flaps and outboard ailerons. It was also fitted with multiple spoiler/airbrakes (items 18 in the detailed drawing overleaf) and a total of eight shallow fences (in the drawing marked QV). Because of the limited (900kg, 1,984lb) thrust of the Junkers Jumo 004B engines these were arranged in groups of three on each underwing pylon. By late 1947 this engine was in limited production at Kazan as the RD-10, and because they were considered superior to the German originals the engines actually installed were RD-10s. The crew numbered three, and to save weight armour was omitted. A neat tricycle landing gear was fitted, the main tanks occupied the top of the fuselage, a braking parachute occupied a box under the tail, and at the end of the fuselage was a remotely sighted FA15 barrette with superimposed MG 131 guns as fitted to some wartime aircraft such as the Ju 388.

The FSW and primitive engines made this an unattractive aircraft.



Centre: Page from EF 131 maintenance manual, Fig. 10 'covers and flaps'.
Bottom: EF 131 (the only known photograph, enlarged from distant background).

Type 140

Purpose: To improve a German design for a jet bomber.

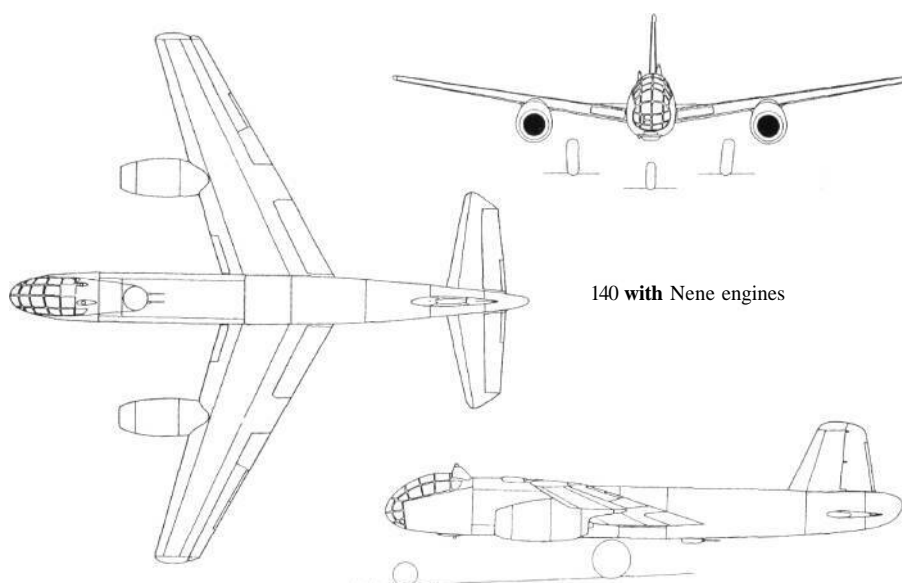
Design Bureau: OKB-1, formed of German engineers led by Dipl-Ing Brunolf Baade (later replaced by S M Alekseyev), at Podberez'ye.

The EF 140 was begun as a private venture by Baade's team, who had faith in their forward-swept designs. The weak feature was obviously the need to use six primitive engines, and work went ahead rapidly to replace these by one of the newer engines which by 1947 were available. These were not only much more powerful, so that the aircraft could become twin-engine, but also had better fuel economy and much longer and more reliable life. The greater power available meant that previous compromises were no longer necessary, and the German team really felt they had a good jet bomber at last. Construction was speeded by using major parts of the second EF 131, so that the first of two EF 140 prototypes began its flight-test programme at Tyopli Stan on 20th September 1948. The flight report described all aspects of the flight as 'normal'. Previously, in May 1948, it has been surmised (because of selection of the IL-28 as a production bomber and rejection of the Tupolev Type 78R reconnaissance aircraft) that the EF 131 should be developed as the 140R purely for reconnaissance. This was countermanded in August 1948 by a SovMin decree that the aircraft should be developed as the 140B/R, capable of flying either bomber or reconnaissance missions. By this time the morale of the Germans was poor. They were surrounded by 'informers', and still had the status of prisoners. In October 1948 Alekseyev, whose own OKB had been closed, was appointed Chief Designer of OKB-1. He set about improving things. He drafted in 50 Soviet engineers, developed a good relationship with Baade, the informers' room was taken by the factory chief controller, the control post between Podberez'ye village and Kimry

was removed, and the Germans were given a better status. As military personnel at Tyopli Stan objected to the Germans being there, the flight-test programme was moved to the airfield at Borki, which was in any case nearer. The test programme of the 140R (the Germanic prefix 'EF' tended to be dropped) was opened on 12th October 1949, the pilot being I Ye Fyodorov. It flew again on the following day, but as speed built up wing flutter was experienced. The 140R spent the next nine months shuttling between the factory and the airfield. In July 1950 the second prototype, in B/R configuration, was well advanced in ground testing, and about to fly, when the entire programme was terminated.

The 140 differed from the EF 131 principally in having only two engines, of new types. These engines were the imported Rolls-Royce Nene, the Soviet derivative known as the VK-1, and the all-Soviet Mikulin AM-01, also known as the AM-TKRD-1. One Russian account states that the 140 first flew with the Mikulin axial engines, experienced problems,

was re-engined with VK-1 centrifugal engines and was then fitted with wingtip tanks. Photographs show that flight testing was carried out with Nene or VK-1 engines without tip tanks and with the Mikulin engines with tip tanks. Moreover, the British centrifugal engine was available in 1947, before the Mikulin engine was cleared for use as sole propulsion (though it had flown under a Tu-2). Despite this, the Soviet record states that on the first flight the engines were the AM-TKRD-1, each rated at 3,300kg (7,275lb). Development of jet fighters was judged to have made the EF 131 armament inadequate, and it was replaced by the outstanding remotely-controlled electrically driven turret with twin NS-23 cannon developed for Tupolev heavy bombers. The 140 was armed with two of these turrets, one behind the pressure cabin and the other under the rear fuselage. To share the workload a fourth crew-member was added, the complement now comprising the pilot at left front with the navigator/bombardier on his right, the dorsal gunner facing aft behind the



Dimensions (Type 140)

| | | |
|-----------|---------|------------------------|
| Span | 19.4m | 63ft7y ₄ in |
| Length | 19.8m | 64 ft m in |
| Wing area | 59.1 nf | 636ft ² |

Weights

| | | |
|--------|-----------|-----------|
| Empty | 11,900kg | 26,235lb |
| Loaded | 23 tonnes | 50,705 lb |

Performance

| | | |
|----------------------|---------|-------------|
| Max speed (measured) | 904km/h | 562 mph |
| Range | 2,000km | 1,242 miles |



Right: 140 with Nene engines.

pilot and the radio operator behind the navigator and controlling the ventral turret. The optical sighting was derived from that of the Tu-4, and in emergency either gunner could manage both turrets. Full armour was restored. The capacious bomb bay had electrically driven doors and could accommodate various loads up to 4,500kg (9,921 lb). The fuel system was completely redesigned, with tanks along the top of the fuselage. The 140 suffered from malfunction of the fuel-metering unit on the AM-TKRD-01 engines, which caused engine speed to fluctuate erratically in a way that the pilot could not control, and which could lead to dangerously asymmetric power. After Flight 7 the engines were changed, and OKB-1 flight testing was completed on 24th May 1949.

Type 140R

To achieve the necessary range, this aircraft was (the Soviet record states) fitted with 'newer, more economical' VK-1 engines derived by V Ya Klimov from the Rolls-Royce Nene, even though these were rated at only 2,700kg (5,952 lb). The span was increased, and fixed tanks were added on the wingtips, increasing internal fuel capacity to 14,000 litres (3,080 Imperial gallons). The former bomb bay was redesigned to carry a wide assortment of reconnaissance cameras, as well as high-power flares and flash bombs in the forward bay and in the fuselage tail.

Type 140B/R

Never completed, this aircraft was intended to have an improved fire control system, the

crew reduced to three, and to have a range of 3,000km (1,864 miles) at 12,000m (39,370ft) carrying 1.5 tonnes (3,307lb) of bombs and 9,400 litres (2,068 Imperial gallons) of fuel.

Always handicapped politically by their ancestry, these aircraft were merely an insurance against failure of the first Soviet jet bombers such as Ilyushin's IL-22 and Tupolev's Tu-12. They were finally killed by inability to solve the structural problems of the forward-swept wing.

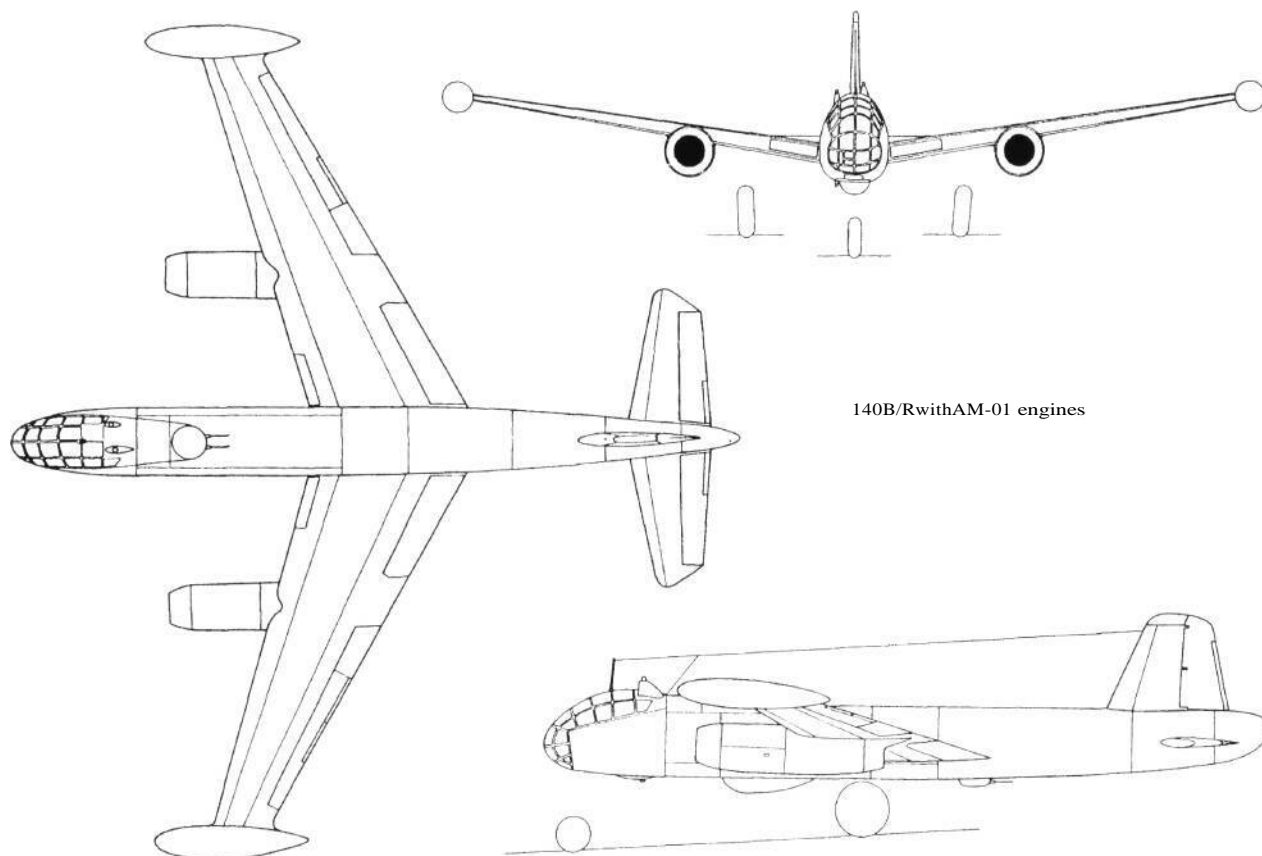
| Dimensions (Type 140R) | | |
|------------------------|---------------------|---------------------|
| Span | 21.9m | 71 ft 10 1/4 in |
| Length | 19.8m | 64 ft 11 1/4 in |
| Wing area | 59.1 m ² | 636 ft ² |

Weights
Not recorded

| Performance | | |
|--|----------|-------------|
| Max speed (measured) | 866 km/h | 538 mph |
| Range at a cruising altitude of 14,100m (46,260ft) | 3,600 km | 2,237 miles |



Left: 140B/R with AM-01 engines.



Type 150

Purpose: Experimental jet bomber.

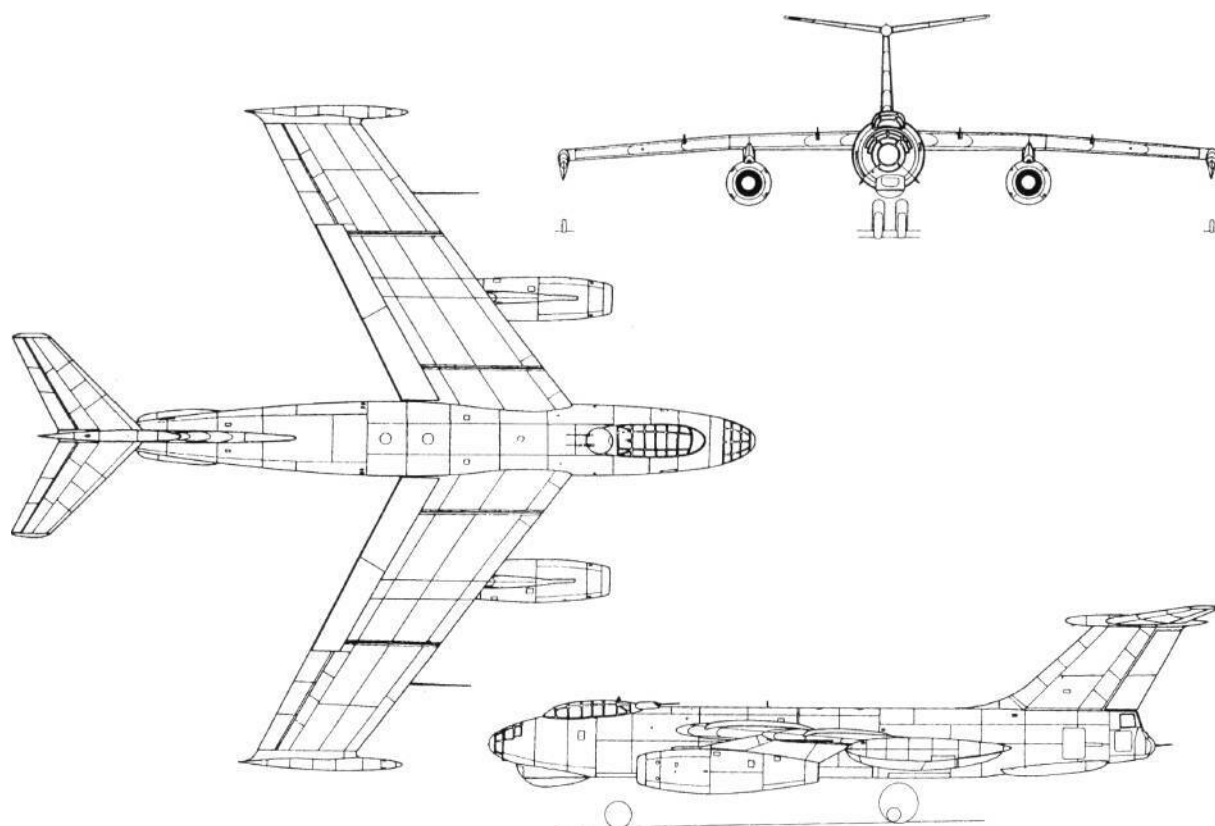
Design Bureau: OKB-1, Podberez'ye and later at Kimry, General Director from October 1948 S M Alekseyev.

The first official history of OKB-1 to be published (in Kryl'ya Rodiny for December 1987, written by I Sultanov) stated that it was led by Alekseyev, whose own OKB had been closed, and that this aircraft was 'designed in close collaboration with CAHI (TsAGI), the leading experts on aerodynamics and structures being V N Belyayev, A I Makarevskii, G P Svishchev and S A Khristianovich'. At the end it briefly noted that 'a group from Germany, led by B Baade, participated...' It would have been more accurate to explain that OKB-1 was specifically formed on 22nd October 1946 in order to put to use several hundred German design engineers, led by Prof Brunolf Baade and Hans Wocke, who had been forcibly taken with their families to a location 120km east of Moscow where they were put to work in a single large office block. For the first three years they were fully occupied on the Types 131 and 140 described previously. However, mainly because of doubts that the forward-swept wing would ever be

made to work, even before they left Germany they had completed preliminary drawings for a bomber of similar size but with a conventional backswept wing. By 1948 this had become an official OKB-1 project, called 150. The original Chief Designer was P N Obruchov, but Alekseyev took his place when he arrived. Workers were increasingly transferred to the 150, which grew in size and weight from the original 25 tonnes to produce a bomber intermediate between the IL-28 and Tu-16. The brief specification issued by the WS called for a take-off weight between 38 and 47 tonnes, a maximum speed rising from 790 km/h at sea level to 970km/h at 5km, a service ceiling of 12.5km and a range varying with bomb load from 1,500 to 4,500km (932 to 2,796 miles). Only a single flight article was funded, and this had to wait a year for its engines. At last it was flown by Ya I Vernikov on 14th May 1951. On Flight 16 on 9th May 1952 the aircraft stalled on the landing approach, and though the aircraft was marginally repairable nobody bothered, because of the clearly greater potential of the Tu-88 (prototype Tu-16). The dice were in any case loaded against a German-designed aircraft. In late 1953 Baade and most of the Germans re-

turned to their own country, where in Dresden they formed a company called VEB which used the Type 150 as the [highly unsuitable] basis for the BB-152 passenger airliner.

A modern all-metal aircraft, the 150 had a shoulder-high wing with a fixed leading edge swept at 35°. As this wing had hardly any taper the tips were extraordinarily broad, leaving plenty of room for slim fairings housing the retracted tip landing gears. The concept of tandem centreline landing gears with small wheels at the wingtips had been evaluated with Alekseyev's own I-215D. At rest the wing had anhedral of 4°, reduced to about -1° 20' in flight. Each wing had two shallow fences from the leading edge to the slotted flap. Outboard were three-part ailerons. The fuselage was of circular section, tapering slightly aft of the wing to oval. Fixed seats were provided in the pressurized forward section for two pilots, a navigator/bombardier and a radio operator who also had periscopic control of a dorsal turret with two NR-23 cannon. Under the floor was the RPB-4 navigation/bombing radar, with twin landing lamps recessed in the front. Behind this was the steerable twin-wheel nose gear. Next came the large bomb bay, 2.65m (8ft 5in) wide and high and 7m (23ft)



long, with a load limit of 6 tonnes (13,228 lb). Next came the rear twin-wheel truck, which on take-off could be suddenly shortened to tilt the aircraft $3^{\circ} 30'$ nose-up for a clean liftoff. The large fin was swept at 45° , with a two-part rudder and carrying on top the 45° -swept tailplane and three-part elevators with dihedral of 8° . In the tail was a rear gunner with a turret mounting two NR-23 cannon. Under each wing was a forward-swept pylon carrying a Lyul'ka AL-5 turbojet rated at 4,600kg (10,101 lb). A total of 35,875 litres (7,892 Imperial gallons) of fuel was housed in eight cells along the upper part of the fuselage, and additional tanks could be carried in the bomb bay. On each side of the rear fuselage was a door-type airbrake. Like almost everything else these surfaces were operated electrically, the high-power duplicated DC system including an emergency drop-out windmill generator. Each flight-control surface was operated by a high-speed rotary screwjack.

Though flight testing revealed some buffeting and vibration, especially at full power at high altitude, the numerous innovations introduced on this aircraft worked well. Nevertheless, it would have been politically undesirable for what was essentially a German aircraft to be accepted for production. Thus, hitting the ground short of the runway was convenient.



Three views of 150.



Dimensions

| | | |
|-------------------------|-------------------|----------------------|
| Span | 24.1 m | 79 ft 1 in |
| Length (excluding guns) | 26.74 m | 87 ft 8 in |
| Wing area | 125m ² | 1,346ft ² |

Weights

| | | |
|--------|-----------|-----------|
| Empty | 23,064kg | 50,847lb |
| Loaded | 54 tonnes | 119,000lb |

Performance

Maximum speed

| | | |
|-----------------------|----------|----------|
| at sea level, | 850 km/h | 528 mph |
| at 10 km (32,808 ft) | 930 km/h | 578 mph |
| Service ceiling about | 13km | 42,650ft |

No other data, except that design range (see above) was exceeded.

Soviet X-Planes in colour

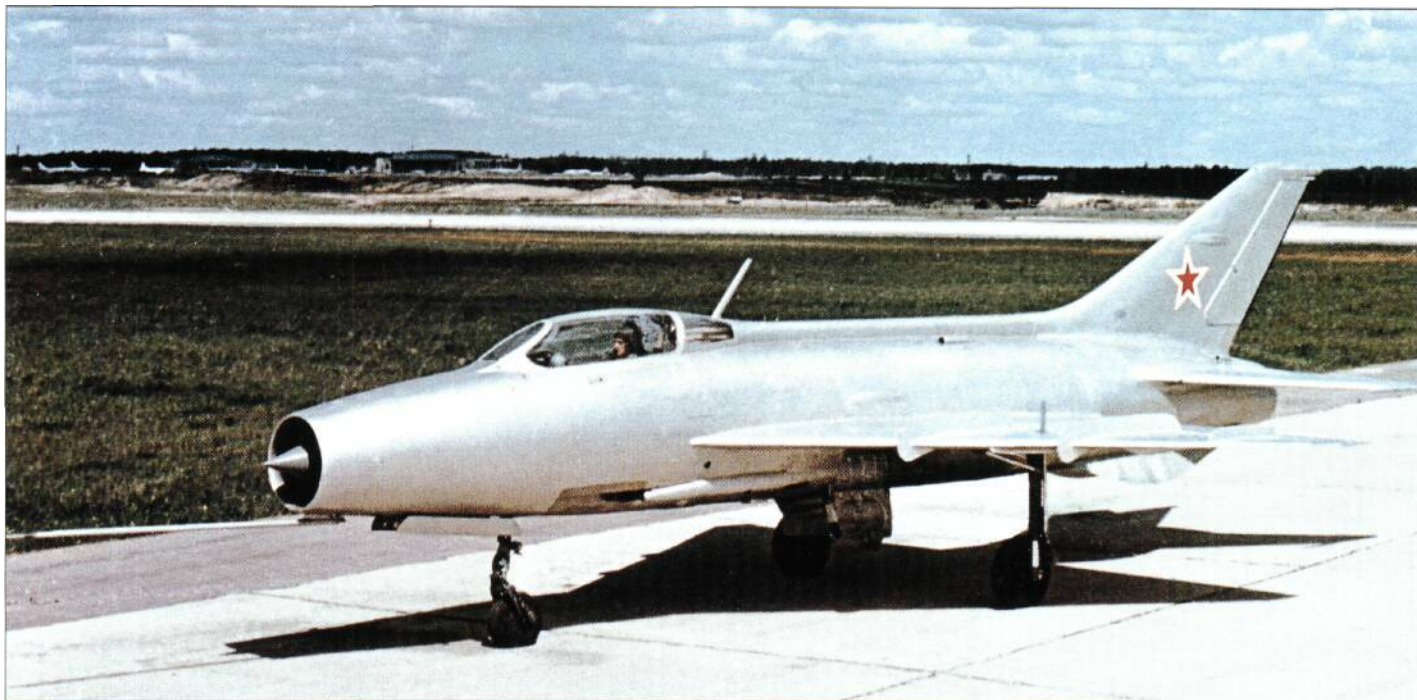
Top: Mikoyan SM-12/1

Centre left: Mikoyan SM-12/3

Centre right: Mikoyan SM-12PMU

Bottom: Mikoyan SM-12PM





Top: Mikoyan Ye-4 with RD-91 engine

Centre: Mikoyan Ye-2A

Bottom: Mikoyan Ye-5



Photographs on the opposite page:

Top: Mikoyan I-3U in late 1956.

Bottom: Mikoyan I-7U.









Top: Mikoyan Ye-152/A with K-9 missiles.

Right and bottom: Two views of the Mikoyan Ye-152P.



Photographs on the opposite page:

Top and centre: **Two** views of the Mikoyan Ye-8/2.

Bottom: Mikoyan Ye-50/3.







Top and centre: Two views of the MiG-23-01 ('23-01').

Bottom: Mikoyan '105-11' at Monino.



Photographs on the opposite page:

Top: Mikoyan Ye-152M (Ye-166) record version at Monino.

Centre: MiG-211/1 'Analog'.

Bottom: MiG-21PD ('23-31').







Top: One of the Myasischev M-17 prototypes at Monino

Above, right and below: Three views of the Myasischev M-55.

Opposite page: Three views of the Mikoyan 'I-44'.







Top: Sukhoi T6-1 test-bed at Monino.

Centre. Sukhoi T6-1.

Bottom: Sukhoi T10-1.



Photographs on the opposite page:

Top and centre left: Two views of the Myasischev VM-T.

Centre left and bottom: Two views of the Sukhoi T-4 ('101').





Top: Sukhoi S-22I test-bed.

Centre left: Sukhoi T10-3.

Centre right: Sukhoi T10-24.

Bottom: Sukhoi T10-20 record version at Khodynka.

Photographs on the opposite page:

Top and centre: Two views of the Sukhoi P-42 record aircraft.

Bottom left and right: Two views of the Sukhoi Su-27UB-PS test-bed.









Three views of the Sukhoi S-37, the lower two taken at the MAKS-99 air show. ,



Photographs on the opposite page:

Top: Sukhoi Su-37 (T10M-11).

Bottom: Sukhoi Su-37 'Berkut'.





Top: Tupolev Tu-155 test-bed at Zhukovskii.

Centre: Yakovlev Yak-141 at Khodynka.

Bottom: Yakovlev Yak-141 second prototype.



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